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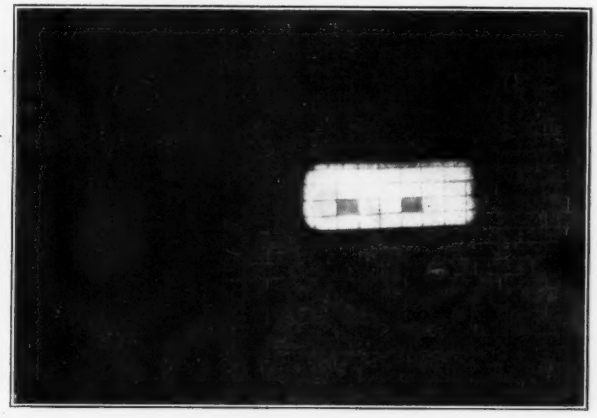


John and His Five Wits

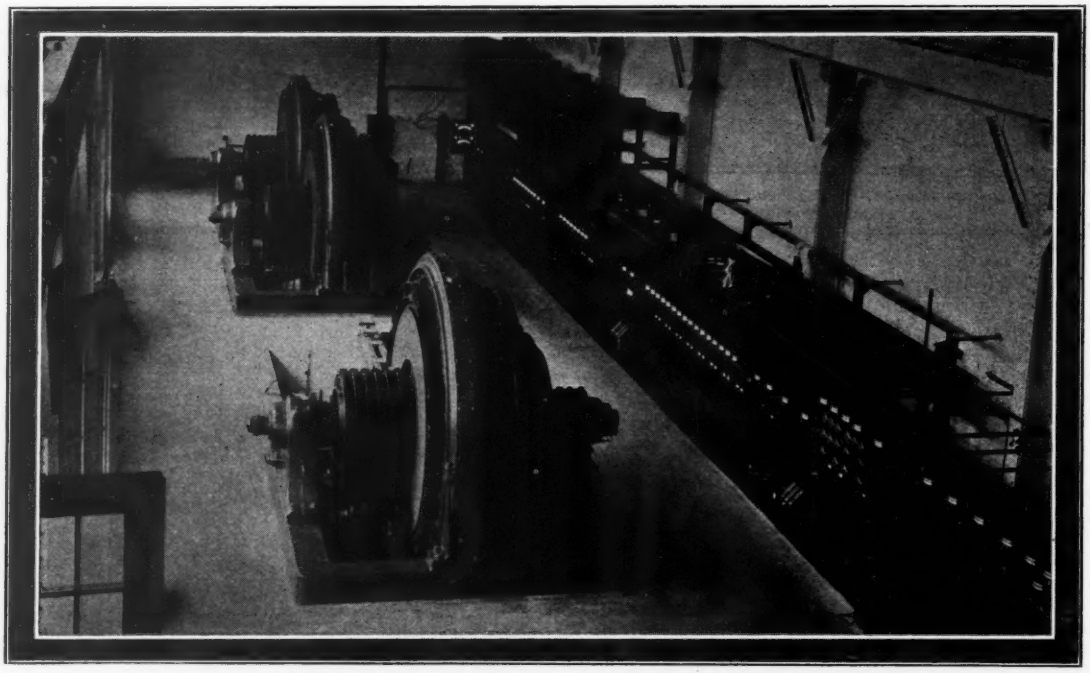
TIME, TIME, TIME! Nothing but time and a little ray of light that came each day through the small grated opening in the top of his prison. With these elements, the imprisoned John Ishcabaro built up in his mind an hypothesis that his body, if acutely developed, would reveal all information that instruments are depended upon to secure. Upon this, he worked to perfect his five senses.

His sense of touch became so accurate that by merely feeling an object he could tell its specific gravity with an accuracy of an ordinary school laboratory. So delicate was it that he could recognize, by their atomic vibrations, the difference between elements and compounds. His taste and smell grew to be a veritable laboratory for qualitative chemical analysis. Why, with this sense of smell, he could even detect the approach of birds flying over his peep hole and name their species.

"Two ears to hear with and we use only one! With two I'm going to measure distances." The variation in volume of sound between the two ears proved to be sufficient for him to determine distances with extreme accuracy and day after day, as the mail airplane went over his dungeon, he charted its course over the town, its height above ground and the speed of its travel.

And sight, marvelous! From utter darkness, as we know it, to gazing directly at the noonday sun, his vision was perfect. The myriads of facts which John Ishcabaro learned through his senses as instruments and that grated opening—

Oh, I forgot to tell you, the picture above is not a dungeon window, but a peep hole into a gas-fired furnace while in operation—mighty clear flame, isn't it? Well, if you want an easy way to calculate gas fuel requirements and stay out of the bug house, just turn over to page 369.



Substation for

WESTVACO CHLORINE PRODUCTS CO. Has Many Novel Features

ABOUT TWO YEARS AGO, the H. K. Ferguson Co. of Cleveland, O., started a general reconstruction and enlargement program at the plant of the Westvaco Chlorine Products Co. at South Charleston, West Virginia, which included the construction of a new electrical substation. This substation, which has recently been completed, possesses several interesting features of design, the work being directed by F. W. Buck, chief mechanical engineer of the H. K. Ferguson Co.

To secure an efficient and accessible arrangement of the apparatus in the limited space that was available at the point where the energy was required was the most difficult feature of the work. A high load factor demanded a high overall efficiency and since the plant must operate 24 hr. a day without shutdowns, a high degree of dependability was necessary.

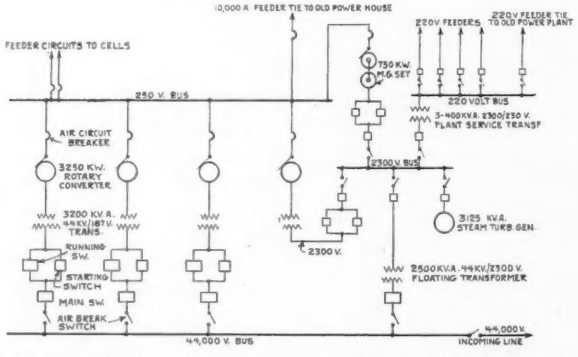


FIG. 1. SINGLE LINE WIRING DIAGRAM OF ELECTRICAL CONNECTIONS

Approximately 80 per cent of the power used in the plant is purchased from a public utility. As steam is used in some of the plant processes, part of the power is generated by turbines operating noncondensing and the rest of the power is received from the lines of the local power system. Therefore in extending the plant, additional converter capacity and additional process steam had to be provided. How this was done is shown in the schematic diagram, Fig. 1. The entire project was completed in less than eight months without interrupting the operation of the plant.

Some Novel Features of Substation Design

The 44,000-v. line is brought in on a steel switching structure where the 44,000-v. bus, air break switches, oil switches and transformers are located. The building itself houses the rotary converters, switchboard, d.c. air circuit breakers, a steam turbine generator which is used to maintain the plant heat balance, and necessary auxiliaries. A general view of one end of the station is shown in the view at the head of this article.

The main units are 3250-kv-a. rotary converters, 187 v. on the a.c. side and 250 v. on the d.c. side, six-phase diametrical, with commutating poles and running at 300 r.p.m. Each unit is supplied by a 3200-kv-a.

44,000/187-v., three-phase, oil insulated self-cooled transformer with all six leads brought out for the six-phase connection.

Y-Delta Starting on 44,000-V. Side

One of the first problems to be met was the starting of these units. The conventional method would probably have been to use a Y-delta connection on the 187-v. side of the transformers; however, since the full load current taken by the converters at 187 v. is about 6700 amp., it will be seen that this scheme would mean a large amount of copper, a large labor cost on the bus work and large circuit breakers.

which the size of the complete switching bay for each unit was only 19 ft. long, 36 ft. wide and 35 ft. high, and complete accessibility to the oil switches was retained.

Normal clearance between conductors is 4 ft. except at switch bushings, etc., where it is determined by the apparatus. The clearance to ground is the minimum established by the insulators used. The switch tower is constructed of single members rather than latticed members. Although the weight is greater, the cost erected was less and it is believed that the appearance and durability are better. Due to the presence of various vapors in the air and the fact that the incoming line is

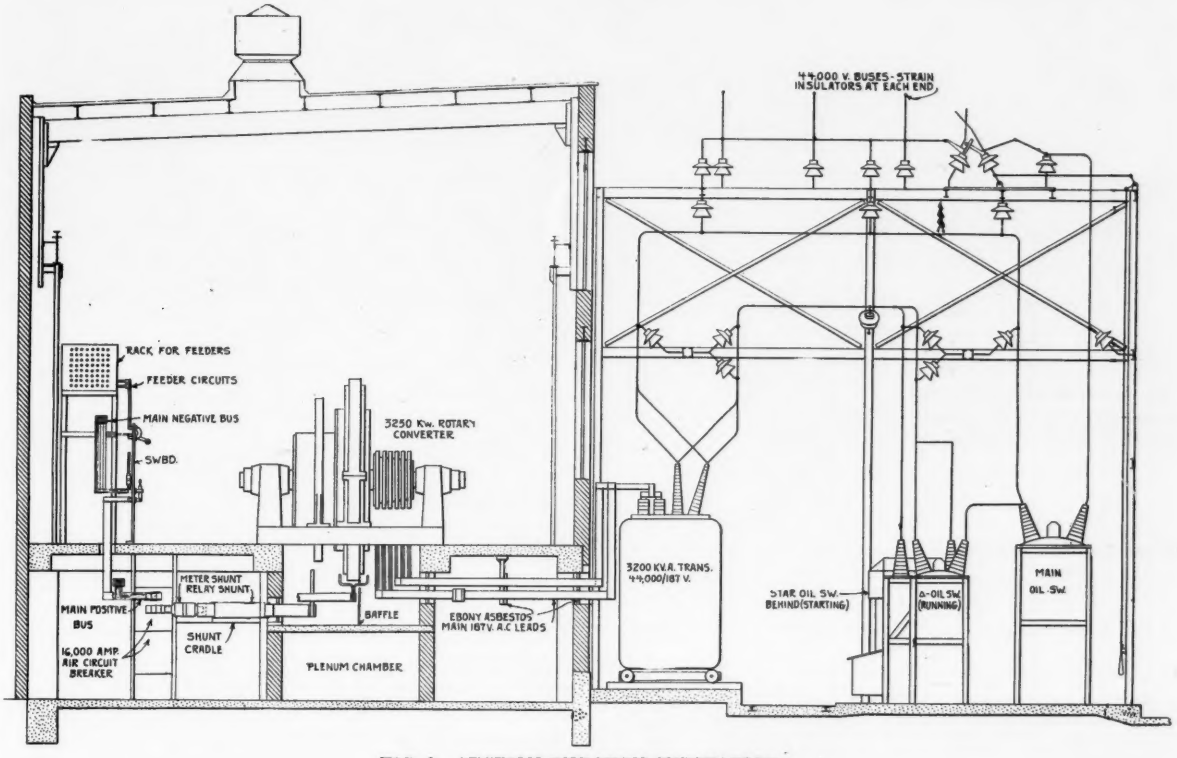


FIG. 2. SECTION THROUGH SUBSTATION

After an economic study was made, it was seen that several thousand dollars could be saved on each unit if the Y-delta starting connections could be made on the 44,000-v. side, allowing for the high cost of the high voltage oil switches. Since the full load current per unit on the high voltage side was only 46 amp., it will be seen that there was also a higher factor of safety and reliability on the oil breakers than if breakers were used on the low voltage side.

A search was made for a precedent but none could be found in which Y-delta starting was used on primary voltages over 13,000; however, it was decided to use that scheme for this station. The three-pole delta and two-pole Y switches are rated at 600 amp. The main switch is also rated at 600 amp. but is of a larger and more rugged type, necessary to secure sufficient short circuit interrupting capacity. When under load the circuit is always broken by this main switch.

All the starting connections are made in the outdoor switching structure with ¾-in. copper tubing. After several studies were made, a design was adopted in operated delta, it was decided to use insulators rated at 73,000 v. Even with this excessive size, it has proven necessary to clean them frequently.

Compact Arrangement of Station Equipment

Inside, the converter station is designed to secure the simplest arrangement of the heavy buses and greatest economy in copper and space. This is shown in Fig. 2, which is a typical cross section through the station. The a.c. leads go directly from the transformer terminals to the rings of the converter and the positive d.c. leads directly from the machine through two shunts and the 16,000-amp. circuit breaker to the positive bus, which is supported on the ceiling of the first floor.

Negative leads go directly to four 4000-amp. switches in parallel on the converter panel and from there to the main negative bus which is supported on a steel framework back of the switchboard which is on the main floor. This framework also carries the feeders which distribute the energy to the electrolytic cells.

FIG. 3. ONE OF THE FEEDER RUNS AND A JUNCTION POINT

The switchboard is composed of 51 panels and the total length is 93 ft. Liberal provision is made for future circuit extensions. It is arranged so that the panel controlling each converter is located opposite the converter. This gives the greatest economy of bus work and all the controls for the converter are on that panel. The feeder circuit panels are between the converter panels and each panel carries the switches, circuit breakers and ammeters for two circuits.

Panels controlling the steam turbine generator, incoming line and auxiliaries are grouped at one end, together with some panels for controlling 220-v. a.c. lines for plant service. Tie buses of liberal capacity, both d.c. and a.c., are provided to the old power house. All 2300-v. and 220-v. oil switches, the 2300-v. buses, field rheostats, etc., are located on the first floor which is readily accessible, but only to authorized persons. Figure 4 shows a view of the single pole main air circuit breakers for the units which are rated at 16,000 amp. and are full automatic trip free so that they cannot be closed on overload.

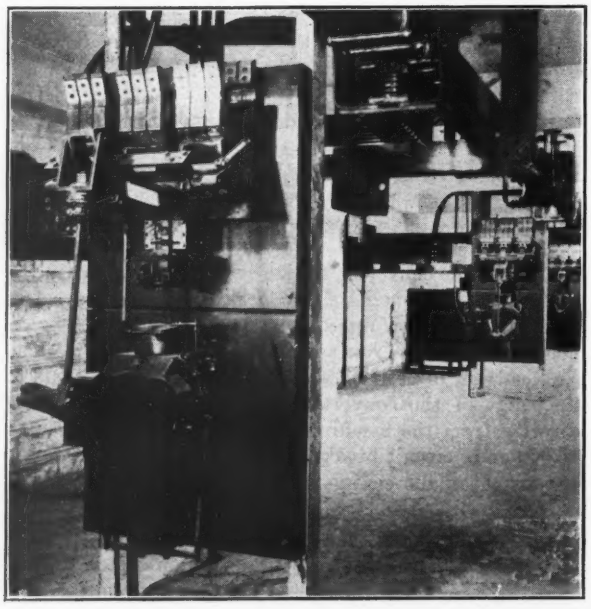


FIG. 4. SINGLE POLE AIR CIRCUIT BREAKERS, RATED AT 16,000 AMP.

All switch closing coils and auxiliary controls are wound for 250 v., except the trip coils. The trip coils are all on a separate circuit operating from a 48-v. storage battery. The object of this is to secure the maximum reliability in the opening of all breakers. All controls are interlocked so that it is impossible to carry the starting sequence through improperly.

Airwasher Keeps Out Corrosive Gases

Washed and cooled air is supplied to the converters for ventilation. There is a plenum chamber which extends under all the machines. The ventilation to each machine is controlled by dampers and a baffle which separates the air delivered to the commutator end from that delivered to the collector ring end. The system is designed to deliver 10,000 cu. ft. per min. to each machine, under a pressure of 1¼ in. of water on the plenum chamber side of the dampers.

Incoming air is passed through a washer in which about 1 per cent of sodium hydroxide has been added to the wash water. This is to remove any injurious gases which may be present, as well as dust. The entire building is closed in so that the only air entering is that which has passed through the washer.

Copper Rod Feeders

Due to the gases in the air around the plant, a piece of copper left exposed will turn black within a few hours. It was necessary to work out some protection against this condition. The problem was solved by greasing every piece of copper with vaseline as soon as it was taken out of the packing case. Then, after it was fabricated and erected, the vaseline was washed out with gasoline and the copper given a coat of a lacquer having a rubber base.

Distribution feeders were carried overhead from the rack back of the switchboard in racks to the points of

distribution. From there they are carried in conduit to the cell banks. The overhead feeders are bare round copper rod, varying from 1 to 1⅜ in. in diameter. They were designed to give a uniform voltage drop at the terminals.

Feeder supports are made of 1½-in. ebony asbestos drilled and then slit on the center line of the conductors. They are spaced about 10 ft. apart and the conductors are spaced 4 in. on centers. Extra supports were added at turns and junction points. A view of one of the runs of feeds and a junction point is given in Fig. 3.

All joints were made by means of a split copper sleeve made from extra heavy copper tubing, slit the full length and then rolled on an arbor to give 1/32 in. on each side for solder. The ends were beveled. Ordinary solder and flux were used. In applying the solder in the sleeves, it was necessary to heat them with an acetylene torch as the bar conducted the heat away from the joint rapidly. This type of joint was found to be very satisfactory.

For testing the joints, a current of 150 amp. was passed through the conductor to be tested and the voltage drop through the joint and through an equivalent length of conductor was measured by means of a Leeds and Northrup potentiometer graduated to read in millivolts. The joint conductances averaged from 25 per cent to 33 per cent better than an equivalent length of rod.

One of the converters is operated from a transformer which is wound for 2300 v. on the high side. It can be operated from the 2300-v. buses which are supplied by the steam turbine generator. The 2300-v. buses are also arranged to be tied in to the 44,000-v. buses through a floating transformer bank as shown in Fig. 1. Therefore this converter can be supplied either from the turbo-generator or the incoming lines, or the turbo-generator can supply energy to the 44,000-v. lines. The turbine is operated noncondensing and the exhaust steam is used in the plant processes. By means of this connection, the turbine can be operated at the proper load to furnish the desired amount of steam and the heat balance can be maintained by taking the rest of the energy from the 44,000-v. line.

In designing the bus bars for the d.c. side, the current density was established at 1000 amp. per sq. in. On the a.c. leads from the transformer to the converters, the density was decreased to 510 amp. per sq. in. and the bars were arranged in two groups so that the copper was distributed as nearly as possible in the form of a circle. Tests made after the installation was completed indicated that although these values were safe they were not unduly conservative.

Operation of the plant was fully up to the expectations. The starting scheme used is exceedingly successful and the machines start smoothly and with no surging. Neither the power company nor the adjacent customers have complained of any voltage variations on their lines. Construction was started on March 17, 1927, and the scheduled date of completion was March 1, 1928. The first converter unit went on the line September 1, 1927, and the entire station was completed by November 1, 1927.

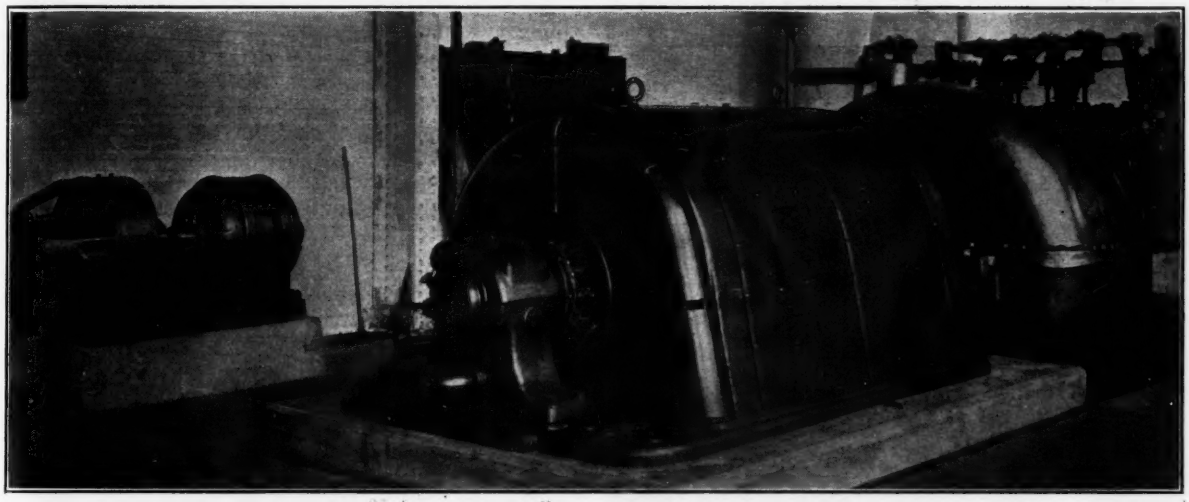


FIG. 5. TURBINE GENERATOR USED TO MAINTAIN HEAT BALANCE

The station was designed and built and the machinery installed by the H. K. Ferguson Co. The subcontract for the electrical work on the station was handled by the Dingle-Clark Co.

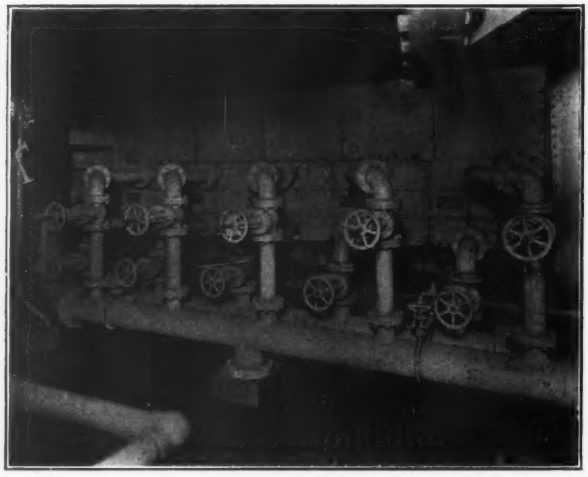
COMMERCIAL STOCKS of bituminous coal used largely for industrial purposes amounted to 41,800,000 t. on January 1, 1929, according to a survey just completed by the Department of Commerce, through the United States Bureau of Mines. In comparison with the amount reported on October 1, the date of the last previous survey, this is an increase of 700,000 t. Exports during the fourth quarter of 1928 averaged 359,000 t. a week against 399,000 t. in the previous quarter and 273,000 t. during the fourth quarter of 1927. The weekly rate of home consumption during the fourth quarter averaged 10,416,000 t., slightly more than in the corresponding period a year ago. In addition to the stocks in the hands of consumers, there were 8,317,603 t. of bituminous coal on the docks of Lakes Superior and Michigan on January 1, 1929, in comparison with 8,409,453 t. on January 1, 1928. The stocks of domestic anthracite held by the coal merchants reporting are close to the average for this season in recent years.

Design and Operation of Generator Air Coolers

PART III. THIS, THE CONCLUDING NUMBER OF THE SERIES DEALS WITH METHODS OF INSTALLING COOLERS AND DUCT WORK DESIGN. BY E. WAINWRIGHT JOHNSTON*

IN AN IDEAL installation, the cooler is placed directly below the generator with the tubes running in a horizontal plane perpendicular to the generator axis. The air, on leaving the generator, passes down through the cooler in a vertical direction and after being cooled is conveyed back to the generator through two return ducts. This arrangement was illustrated on page 255 of the February 15 issue.

Water or condensate enters the unit at the lower connection so that the coldest water is in contact with the coldest air and the warmest water with the warmest air, creating a counterflow condition which gives a higher mean temperature difference than a parallel flow unit, therefore requiring less surface to obtain a given rate.



DOUBLE BANK U-FIN AIR COOLER FOR A 30,000-KW. GENERATOR

In such an installation, the cooler ordinarily rests on structural steel supports which run throughout the entire length of the shell, one support on the extreme left, one support on the extreme right and one between each section when the cooler is made up of more than one section in a single bank. These supports run lengthwise of the shell. No cross supports are necessary. When the cooler is supported in this manner, little danger exists of cutting down the area of air inlet and discharge. The area of these openings have been carefully determined by the designer and any obstruction to air flow would probably interfere with the operation of the cooler. Great care should be taken to see that these openings are not obstructed by supporting members.

STRUCTURAL BEAMS SUPPORT CONDENSER BANK

One good method of supporting the upper or condensate bank of a double bank unit is to rest it on structural steel beams, which in turn, rests on the lower or raw water bank. As these two banks are usually made up of the same number of sections of the same length and width (the difference in surface being in depth), this can be done without obstructing the air opening. It would not be necessary to provide any method of supporting the beams on which the condensate bank rests, the entire weight coming upon the raw water bank. Beams so inserted between the two banks would act as a spacer, providing ample clearance between the banks for removing the water head of any single section without danger of interference from the respective section of the other bank.

In cases where there is no space available for providing clearance as specified above, the writer would recommend installing coolers of the U-tube construction which have water heads on one end only. Units so designed should be installed with the heads of the condensate bank on the opposite end from those of the raw water bank. This would allow ample clearance for removing the heads. The accompanying illustration shows the Griscom-Russell double bank U-fin cooler installed in this manner.

Space limitation frequently prevents installing coolers as recommended above and as a result various methods have been developed. The most important of these the writer will discuss below.

SUPPORTING COOLERS FROM FLOOR BEAMS

Coolers have been hung from the floor directly under the generator in the same position as just described. Where this is done, structural steel beams which run lengthwise of the cooler shell are bolted to the top or bottom of the cooler frame. Steel straps, hung from the floor beams of the building, are bolted to the ends of these reënforcing beams. Holes are drilled in the cooler frame for holding the duct work and reënforcing beams.

If the space below the generator is too narrow to permit a sufficient number of sections from being installed as shown above, they are frequently installed on their sides, the air passing through the coolers in a horizontal direction.

Where four sections are required and the head room as well as the width of the space provided for the coolers is limited, the sections are installed on their sides as before but divided; that is, two sections are placed on each side so that half of the total quantity of air passes through each two sections in a horizontal direction. Thus we have half the air passing through half the surface, therefore it is cooled to the required temperature when half the total amount of cooling water passes through each pair of these sections in parallel.

In laying out the duct work for an installation of this type, the engineer should take particular care to see that the return ducts have approximately the same resistance to air flow; otherwise, the air would follow the path of least resistance and as a result more would pass through the cooler sections on the side having the least resistance than through those on the other side and the air in the former case would not be cooled sufficiently,

*Engineer, The Griscom-Russell Co.

while that passing through the other side would be cooled to a lower temperature than necessary. This, of course, would cause uncertain ventilation and cooling of the generator windings.

In cases where the floor space is extremely limited, cooler sections are frequently installed with the tubes running in a vertical direction; the air passes through these units horizontally. Coolers so installed may be divided into two groups as in the above case. Of course, each group will preferably have the same number of the same sized sections so that the area of air passage will be uniform on each side, (in order that the resistance to air flow will be equal).

Coolers installed vertically are supported by wall brackets, hung from the floor above, or stood on end, resting on the floor or on trucks, the last mentioned method being particularly convenient in removing the sections to where there is ample room for cleaning and repairing.

Installation of Ducts for Cooling Air

Not much can be said concerning the support of the duct work in an air cooler installation as this varies greatly with the local conditions for each installation due to the location of columns, beams, etc. Little difficulty will be encountered in this respect, however, under ordinary conditions.

Air ducts should be as short as possible and of a good-sized cross-sectional area in order to keep the air friction loss down to a minimum. Sharp turns and sudden changes in cross-sectional area should be avoided, as they create eddy currents which increase the air friction. When the foregoing precautions are observed, the operator will find that the air pressure drop will be small and practically negligible as compared to that of the cooler.

Some engineers prefer to have emergency duct work and dampers so that air may be taken from outside and circulated through the generator when it is necessary to take the cooler out of service for cleaning or repairs. Other engineers prefer an additional section which can be brought into service should it be necessary to take a section down for cleaning. The writer does not believe that either is necessary in the average installation as the chance of taking a cooler out of service is remote and unless the water is extremely dirty the cleaning periods would not be more often than two or three times a year.

In regard to using air from outside for a short period of time, it would be a simple matter to lead a duct from the outside of the building to the return duct work leading from the cooler. This outside duct would be closed by an air-tight damper while the cooler is in operation and the duct leading from the cooler must also be shut off by a damper when the outside air is being used, so that it will not back up through the cooler. Air leaving the generator may be easily prevented from entering the cooler when it is out of service by placing a blanking-off plate over the air inlet opening. A damper opening into a duct leading outside the building may be placed directly over the cooler in the side of the duct leading from the generator. This would prevent hot air from being blown into the room, which would be uncomfortable in warm weather. Of course, this damper would be closed when the cooler is in operation. The air is circulated by fan blades in the generator rotor as before, or in cases where the blowers are used, they should be so placed in the ducts as to be of service for outside air.

Should a spare section be desired in a single bank cooler or in the raw water bank of a double bank cooler, this may be easily installed and blanked off by setting a plate over the air inlet opening. When any section is taken out of service, the valves in the water line of the spare section are open, admitting cooling water, and closed on the section being taken out of service. The blanking-off plate is then removed from the spare section and placed over the opening of the one shut off. Operation is not interrupted during this change.

One of the best known methods of extinguishing fire when started in a generator is by the use of steam. When steam is turned on in the duct work for any length of time, a pressure is built up which may prove injurious to both the duct work and the generator. For this reason, many engineers prefer to use relief doors. The relief door most commonly used is simple and consists of a gasket of shellacked paper held tightly in a frame and covers an opening in the side of the duct work. When pressure is built up within the duct work by the steam, the paper gasket is broken and the internal pressure forces a hinged door open. This door may be built of steel plate, hinged at the top. When the pressure is relieved, the door falls back into place by gravity, preventing air entering which would tend to aid the fire due to the draft created and the presence of oxygen.

Frequently air cooler installations are equipped with thermostatic alarm for warning the operator when the unit fails to cool properly. Such a condition would be brought about by falling off of the supply of cooling water or by an increase in the inlet water temperature.

Thermostatic control which regulates the amount of raw water passing through the raw water bank of a double bank unit is sometimes installed. This device regulates the raw water flow at all times and by so doing the entering air temperature to the cooler is maintained at the same temperature for all loads and thus the maximum amount of heat is absorbed by the condensate and returned to the boiler at all times.

Recent announcement by M. S. Ketchum, dean and director, College of Engineering and Engineering Experiment Station, University of Illinois, Urbana, Ill., states that applications for appointments to research graduate assistantships maintained by the Station should be sent to him not later than April 1, 1929, and that blanks for this purpose will be furnished by him upon request. These assistantships, of which there are 14, have been established to assist in the conduct of engineering research and to extend and strengthen the field of the University graduate work in engineering. Each one carries an annual stipend of $600 and freedom from all fees except for matriculation and diploma fees; they are open to graduates of approved American and foreign technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry. Further details regarding the requirements for nominations and the work conducted by the research graduate assistants can be obtained from the director, M. S. Ketchum, at the above address.

Peak-Load Problems in Steam Power Stations*

Analysis of Various Schemes Proposed to Provide Equipment for Carrying the Annual Peak Loads. By A. G. Christie†

MUCH thought has been devoted to methods of improving the daily load factors of steam-electric power stations. Night loads have been added, power demands for morning and early afternoon hours have been developed, and attention has been given to reducing peak demands which usually occur at about six o'clock in the afternoon. This paper will discuss the problem of carrying the maximum peak loads of the year.

A study of load-duration curves leads to the formulation of two statements regarding peak-load equipment in a generating system: (a) Plant intended for peak-load service only should be installed at the lowest possible first cost; (b) Economy of peak-load equipment can be sacrificed to secure low initial cost. The first statement is evident from a consideration of the few hours of service of this portion of the system during the year. Only equipment with a low first cost can be justified. The second follows from a consideration of the small amount of power generated by such peak-load equipment. The cost of each kilowatt-hour thus generated consists predominantly of fixed charges, with relatively smaller charges for fuel, labor and maintenance.

Proposed Schemes to Carry Peak Load

Electrical systems have had such rapid growth that additional generating capacity is needed every few years. The design of power plant and equipment has also developed so that fuel economies are available by the addition of new units. Each new installation has been made the "base-load" plant of the system, although there have been exceptions to this practice. The high load factors of many systems which have well-sustained high loads throughout the greater portion of the day with no short, sharp peaks favor the addition of base-load units.

High-level water storage, Diesel engines, electric storage batteries, and Ruths steam accumulators have been considered for carrying peak loads.

Few sites are available in this country where the combination of lack of pondage on the river, low load factor, and nearby available natural storage basins at high head would make an economic possibility of hydraulic storage during off-peak hours for use on peak load.

Electric storage batteries for peak-load service are usually limited to those systems which will have Edison direct-current distribution. Few large batteries will be installed except for emergency reserve in order to preserve continuity of the direct-current service. Storage batteries are still of great value for such service in important districts of many large cities. They are costly and are not generally considered economical equipment to carry system peak loads.

Large Diesel engines are being installed in some European systems for peak-load service. Much can be said in favor of Diesel engines for this purpose on account of their quick availability and low stand-by and operating costs. Their future development should be closely watched by power engineers with this possible use in mind. The development of large Diesel engines for central-station service has been slow in America due to high first cost, and on this account it is not likely that Diesels will be widely used for peak-load service in the immediate future.

Steam Accumulators

The steam accumulator has been used for many years both here and abroad for service with exhaust steam from reciprocating engines, and its operation is well understood by engineers. A Swedish engineer, Dr. J. Ruths, applied the principle of steam storage to accumulators for large quantities of steam by making the pressure vary between wide limits—for instance, from 250 to 50 lb. per sq. in. gage. In the following discussion the use of the term "steam accumulator" will refer to one of this high-pressure type.

The steam accumulator finds economic justification in power plants to take violent load fluctuation of short duration, to enable the plant to carry economically sharp daily peak loads, and to carry a portion of the annual peak load.

The application of steam accumulators in industrial power plants with wide, frequent, and rapid fluctuations in steam demand has been described in R. A. Langworthy's paper, The Ruths Steam Accumulator. Central stations which serve street railways, underground railways, and electrified trunk lines have power demands which vary quite as rapidly and between as great extremes of boiler capacity as in many industrial plants, and to which steam accumulators would seem desirable additions.

The cost of an accumulator will depend upon the extent and nature of the fluctuations in steam demand that it will have to meet. If the fluctuations are of short duration, the accumulator installation need not be large. If the fluctuations are of long duration and very irregular, more accumulator capacity will be required and the cost will increase. Where no increase in total station output is anticipated subsequent to the accumulator installation, the fixed charges on the new equipment, including costs of changes on turbines and piping, must be balanced against the savings resulting from better operation of the boiler plant.

Soon a point is reached in electrical systems with growing loads when additional generating capacity must be installed. The choice may lie between additional boiler-house equipment and another standard high-pressure turbo-generator; steam accumulators and a special turbo-generator to carry fluctuations and peak loads; or a special peak-load turbine and boilers. A boiler plant which has been subject to wide fluctuations in load can generally carry a steady load of much higher average

*Abstract of paper presented at the annual meeting of the A. S. M. E.

†Professor of Mechanical Engineering, Johns Hopkins University.

capacity with less difficulty and at better efficiency. Hence the addition of steam accumulators would improve the performance of older boilers, and would also save the cost of additional boilers, boiler house, and coal handling and other equipment. Accumulators are generally placed out in the open with no housing or any construction other than the supporting concrete foundations and the necessary piping and valves.

tages may be secured at slight additional cost by making the accumulator turbine a mixed-pressure turbine capable of operating steadily in emergencies on steam direct from the boilers, or desuperheated.

Steam accumulators are suitable for peak-load service when the peaks are sharp and of short duration.

Old stations on a power system often offer possibilities of increased capacity for peak-load service.

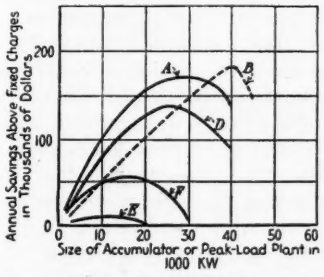


FIG. 1. SAVINGS WITH 65 PER CENT ANNUAL LOAD FACTOR AND $5 COAL

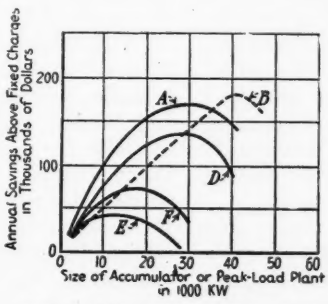


FIG. 2. SAVINGS WITH 65 PER CENT ANNUAL LOAD FACTOR AND $4 COAL

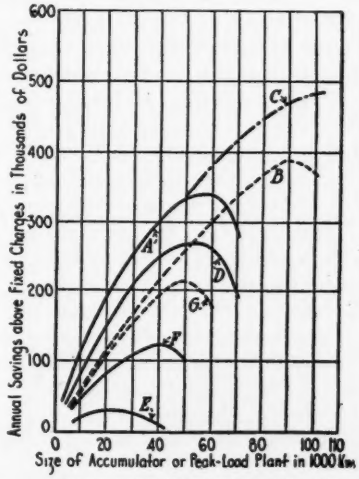


FIG. 3. SAVINGS WITH 45 PER CENT ANNUAL LOAD FACTOR AND $5 COAL

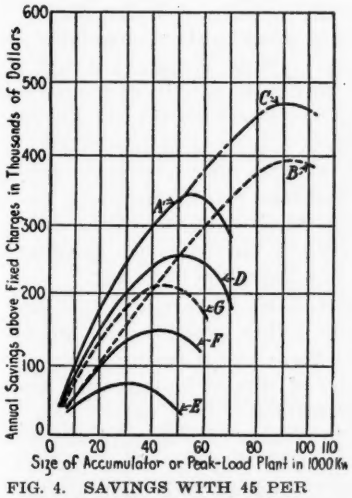


FIG. 4. SAVINGS WITH 45 PER CENT ANNUAL LOAD FACTOR AND $4 COAL

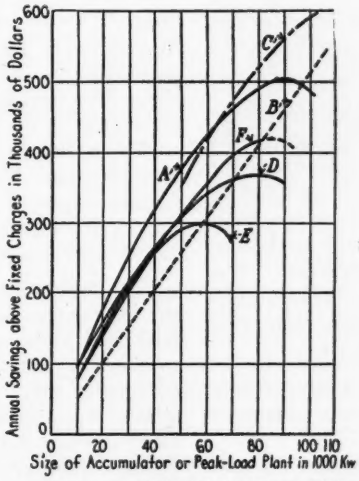


FIG. 5. SAVINGS WITH 25 PER CENT ANNUAL LOAD FACTOR AND $5 COAL

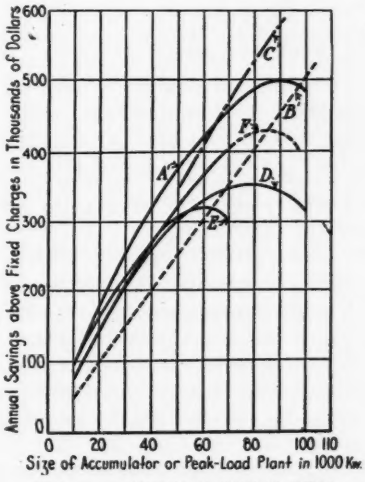


FIG. 6. SAVINGS WITH 25 PER CENT ANNUAL LOAD FACTOR AND $4 COAL

FIGS. 1-6. ANNUAL SAVINGS ABOVE FIXED CHARGES THROUGH THE USE OF STEAM ACCUMULATOR PLANT OR PEAK-LOAD UNIT ON A 200,000-KW. SYSTEM

Curve A—Annual savings, steam accumulator over addition of base-load plant to standard plant.
Curve B—Annual savings, peak-load unit over addition of base-load plant to standard plant.
Curve C—Annual savings, combined accumulator and peak-load plant over addition of base-load plant to standard plant.
Curve D—Annual savings, steam accumulator over addition of standard unit to standard plant.
Curve E—Annual savings, steam accumulator over addition of base-load unit to system with standard plant and old low-efficiency plant.
Curve F—Annual savings, steam accumulator over addition of base-load unit to system with standard plant together with older plant of moderate efficiency and still older plant of low efficiency.
Curve G—Annual savings, steam accumulator over addition of base-load unit to system with a series of units with efficiencies decreasing from the standard plant to the very old plant.

NOTE: The differential between curves A and B at any size of accumulator or peak-load unit remains constant for that particular size. Curves have not been drawn for annual savings with peak-load units for conditions represented by curves D, E, F, and G, as this would confuse the diagrams. The savings by the use of peak-load units with these combinations can be found by deducting the differential between curves A and B from the curve of accumulator savings for the particular system in question.

Steam turbines for accumulators are usually operated on saturated steam at moderate pressures, which permits the use of cast-iron casings. The low annual load factors for peak-load service will not warrant refinements in the design of turbine or condenser plant, and these for use with accumulators should be little, if any, more expensive than similar plant for peak-load service at standard pressures. Some operating advan-

Many have stokers with low settings and old equipment. Some of these may be changed to powdered-coal firing with unit mills, water-cooled furnace walls, evaporators, air preheaters, and radiant-type superheaters, and the output of the boiler plant can thus be greatly increased during peak loads. If adequate cooling water is available, the old turbines may be rebuilt for greater steam capacity at peak load. Small turbines may be replaced

by new, larger, peak-load units. Generators may also be rewound for added capacity, or may be replaced by units of larger output. Such changes will materially increase the capacity of an old plant as a peak-load station, and the resultant gain in system capacity may be secured at a lower total cost than by any other plant which will provide the same additional capacity.

When new and highly economical boilers and turbines are added to a power system and are operated as base-load units during the early years of their use, the capacity factors of the older equipment are decreased. The question now arises, whether the installation of cheap, rugged units of large capacity for peak-load service only, in place of highly efficient base-load units, would be economically justified. It is also desirable to determine whether such peak-load units would provide lower costs than steam-accumulator plant.

These peak-load turbines are of simple design and moderate efficiency so that as great an output as possible may be secured from a given frame, thus lowering the first cost per kilowatt of capacity. Condenser equipment for moderate vacuum may be installed. Peak-load boilers could be either oil fired or provided with water-cooled walls, large furnaces, and unit pulverizers for quick starting, low stand-by costs, and maximum ratings during their short daily periods of operation.

Economics of Methods of Carrying Peak Loads

In order to make some concrete comparisons of the relative economy of steam accumulators, base-load units, and peak-load units, the average daily load curves for a year (for 65 per cent annual load factor and for 45 per cent annual load factor) of a plant with a total capacity of 200,000 kw. have been assumed from data in A. H. Markwart's paper, Power in California.[3] The corresponding load-duration and annual-load-factor curves were drawn and the following plant costs were assumed for the purposes of this discussion:

Peak-load plant complete..... $85 per kw. capacity
Standard plant complete.....$100 per kw. capacity
Base-load plant complete with
latest heat-saving equipment..$115 per kw. capacity

The steam-accumulator plant can be as simple in the turbine room as the peak-load plant. Its cost exclusive of the accumulator was taken as $55 per kw. of capacity. Accumulators with their foundations and piping were assumed to cost $17 per kw-hr. of maximum charging capacity.

Comparisons, the results of which are given in the accompanying curves, are based only on fixed charges and fuel costs with the additional labor. It is assumed that repairs and maintenance, attendance, supervision, and other charges will remain substantially constant in all cases, therefore they are not included in the comparisons, although it would appear that these charges should be less for accumulators than for boilers.

With the assumed cost data and a triangular peak, the steam accumulator loses its advantage if the base of the peak that it is to carry exceeds 4 hr. These studies have been made on load curves with sharp annual peak loads such as occur in some cities with large lighting loads. Calculations indicate that peak-load units are less economical than an accumulator plant except in the large sizes. On the other hand, the availability of peak-load units for emergency service, particularly in the case of long-sustained peak loads on dark days, is greater than that of the accumulator. The same degree of availability may be secured on the accumulator turbine by making it a mixed-pressure unit.

Load-duration curves of systems with broad, flat daily peaks may show a certain portion of the annual peak which has a low annual load factor. The long duration of such daily peaks will favor the installation of a peak-load in preference to steam accumulators.

A steam-accumulator plant could carry peak loads other than during the annual peak, and this would lead to station economies due to the operation of fewer boilers and standard turbines. The charged accumulator is also available for emergencies during off-peak hours such as thunderstorm peaks, fog, etc. The charging of the accumulator with steam during the night would improve the load on the boilers, and this should lead to more efficient boiler-house operation during that period. Accumulators require little maintenance and repairs, and this cost will be less than for the equivalent capacity of the boiler plant. Accumulators are subject to little wear and tear, hence their rate of depreciation should be less than that of a similar capacity of boiler plant. No financial credit has been given to the accumulator plant in this paper for any of these savings, although it is reasonable to expect that these may be of a substantial size. The annual savings shown by the various curves refer only to the annual peak load of the system.

The accumulator, with its lower first costs, saves in fixed charges. The base-load plant saves fuel. The net savings depend on the relative values of these two savings, and as shown by the various curves given in the paper, may amount to a large sum of money.

An important point shown by curves A, B, C, and D in the various figures is that steam accumulators and peak-load units effect their largest savings when added to a system consisting of standard plant with modern equipment only. Accumulators have usually been considered for addition to systems with older plants, whereas this study indicates that they can effect the largest savings when applied to systems with the most modern plants, provided these carry sharp peak loads.

A second striking fact is the large margin of saving that may be secured by the use of accumulators in place of base-load plant to carry annual peaks with any plant combination when the annual load factors are low.

A third point of interest is that the lower the price of coal, the larger the accumulator savings in systems with old and mixed plants, as shown by comparing the curves for different coal prices. This results from the fact that the value of the fuel saving effected by the addition of base-load units is less with low-priced coal than with expensive coal.

It is well to bear in mind in studying the figures presented in this paper that the results refer specifically to the assumed data. While these studies do not consider all possible cases of annual peak loads, they will direct attention to the importance of considering methods of carrying such peak loads and the possible place of steam accumulators and peak-load units in modern central stations. Since each system is a problem in itself, and should be considered separately, this paper may suggest ways of studying the peak-load problems of various power systems.

[3] Jl. Franklin Inst., Aug., 1927.

Lubricant Reclamation

Reduces Power Station Upkeep

Part 1. The process of lubricating oils, purification. Types of purification apparatus, their adaptability and methods of operation

MANY USERS of lubricating oil have learned that properly refined oil, if kept clean, will protect bearings against the ravages of friction until it is actually consumed, evaporated or lost by leakage; while dirty oil will cause increased friction, wear and perhaps heavy repair costs. For many years, every effort has been made by designing engineers to reduce friction in machines; and by lubricating engineers to provide lubricants that will stand the requirements of present day power plant practice but the general practice of oil recovery by means of purification is of comparatively recent origin.

Waste oil from bearings often amounts to a considerable loss. Oil used in splash lubricating systems is often retained long after its useful period. Superior lubrication is secured by means of a pressure system because the increased pressure and greater quantity of oil used tends the better to maintain intact the film of oil. Such a system also provides a means for washing away foreign matter or minute particles that are worn off of the bearing as well as for carrying away sensible heat from the bearing. Under these conditions, much more oil would be used and the method would be prohibitive if it were not for the recovery methods that are now available.

In steam turbine lubrication, due to the very high rotative speeds employed, it is particularly important to remove all water and metallic impurities from the oil. In internal combustion engine practice, the requirements for reclamation are even more severe; not only is it necessary to remove fine, metallic particles, rust and water in order to keep the entire system of oil pipes and inlets free from dirt and sludge; but it is important to remove any carbon, coming from the cylinders due to imperfect combustion, which may have become mixed with the lubricant. Removal of fine carbon particles cannot be accomplished by the ordinary filtering process; coagulation and centrifugal processes have accomplished this successfully.

Oil Reclamation Results in Attractive Savings

Savings secured through reclamation of lubricating oil are due largely to reduction in repair and replacement costs and in labor costs, as well as in the direct saving of lubricant. Analysis of the British Diesel Engine Users' Report on heavy oil engine working costs for 1924-25 shows that the eight plants employing centrifugal oil purifiers were able to generate electricity 27 per cent cheaper than the 24 other plants which did not use centrifugal machines. Centrifuging seems to have caused a reduction in total operating costs, from the gross average for all stations, from 1.61 cents to 1.31 cents per kw-hr. Segregated costs of the 24 non-centrifuging plants averaged 1.79 cents.

As a result of a survey conducted by the National Electric Light Association and covering 80 large steam turbines of from 20,000 to 60,000-kw. capacity, it has been shown that in the aggregate, these units are out of service for more than 2 per cent of the time for the purpose of removing sludge deposits from the lubricating system and to repair damage caused by improper lubrication. In addition to the loss of machine time, there is the expense involved in the labor and materials used in cleaning and in repair.

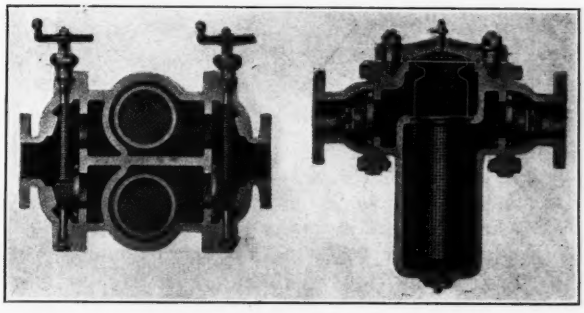


FIG. 1. ELLIOTT TWIN OIL STRAINERS

Essential Processes of Purification

Oil purification consists essentially of three processes, namely, screening, precipitation and filtration, provision for all of which is usually embodied in oil purifiers. Screening is done to retain the coarser impurities and relieve the other sections of the apparatus of as much work as possible. Strainers are usually attached to Diesel engines for this purpose. Precipitation removes the fine impurities of higher specific gravity than the oil, such as fine metallic wearings and water. Filtration is intended to remove the finest floating impurities in the oil. Filtration must be done by the dry process. Passing dirty oil through water does not remove all impurities. The oil rises through the water in drops; impurities are inside the drops and cannot possibly be absorbed by the water however hot that water may be.

Some small oil filters syphon the oil through woolen syphons. Only clean and fairly dry oil will pass through such syphons. Most small filters employ cotton waste, wood-wool or other loose material as a filtering medium, but in larger filters, filter cloth is now universally adopted. Use of loose substances for filter material has the disadvantage that when it is loosely packed the oil passes through without being properly filtered. When it is packed tightly, the capacity is restricted. Filter

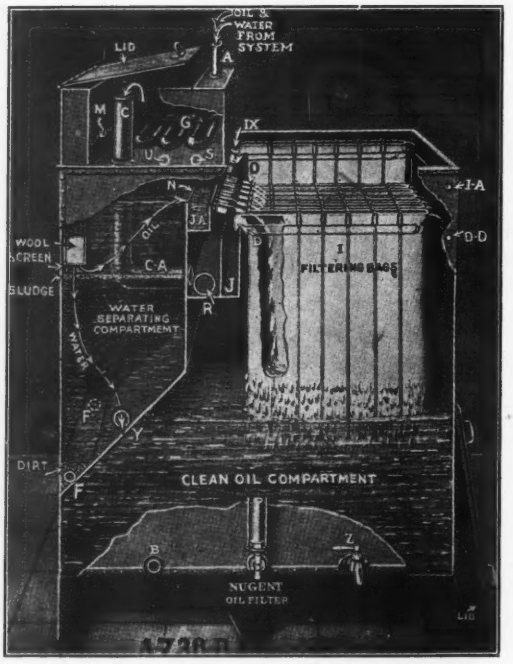


FIG. 2. NUGENT OIL FILTER

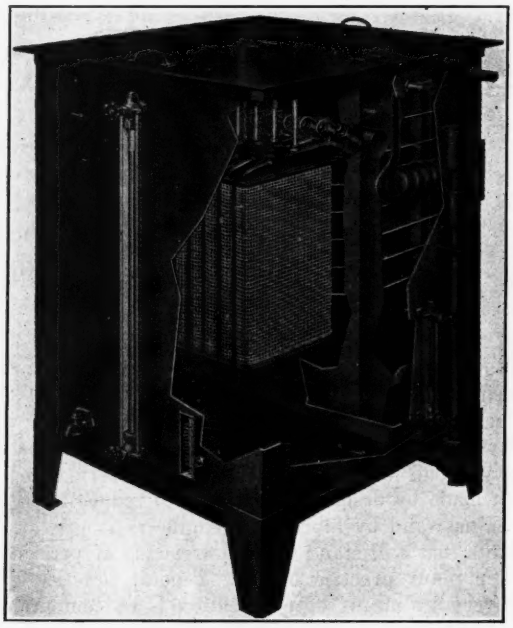


FIG. 3. AMERICAN MODEL W OIL FILTER

cloth in the form of a bag is preferable to loose material. It should be so arranged that the impurities retained have a tendency to drop away from the surface. With horizontal filter surfaces, the oil should therefore pass upward. Vertical filter surfaces are more satisfactory as there is less tendency to clog the filter cloth.

Filter Materials

Strainer cleaning without stoppage of operation may be done by the installation of twin strainers as shown in Fig. 1. Filters using filter bags are illustrated in Figs. 2 and 4. Wire mesh supports the filter bags, which may be removed independently during operation for cleaning. For filtering material, in the filter shown in Fig. 4, a combination of animal bone-black and white waste is recommended. Filtration is accomplished in the filter shown in Fig. 5 by entering the oil at the bottom of one compartment and passing it up through a number of layers of cotton cloth to the top, where it overflows to the second compartment. This procedure is carried out through the three compartments after which it passes out of the top of the last compartment. Figure 6 illustrates a filter in which the successive settling pans are arranged back of the filtration compartment proper, the heating compartment being on top. A pressure filter for oil recovery is illustrated in Fig. 7.

Heating greatly facilitates the filtration process. Exhaust steam or hot water may be used for this purpose and are usually piped to a coil located in the receiving compartment of the filter. The heat thins the dirty oil before it passes through the filter. Automatic arrangements for getting rid of water, when water is mixed with the waste oil, are usually made before the oil to be filtered passes through the filter. Agitation of

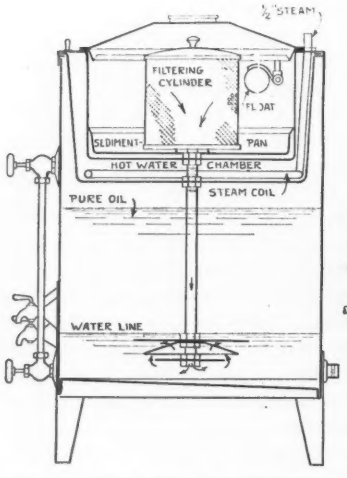


FIG. 4. BURT UNIT OIL FILTER

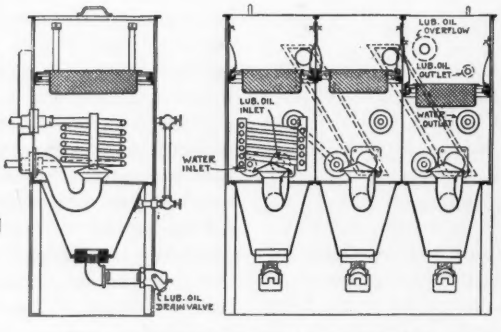


FIG. 6. BOWSER TYPE A OIL FILTER

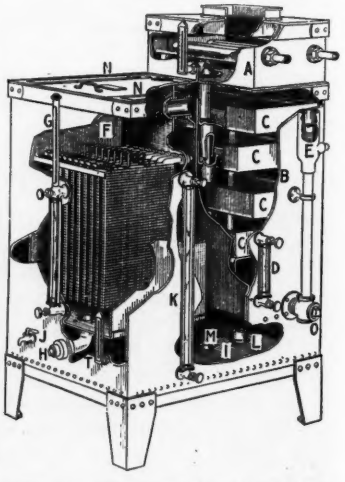


FIG. 5. NORDBERG OIL FILTER

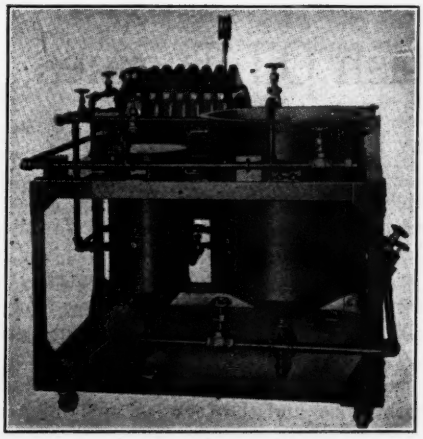


FIG. 7. KELLY PRESSURE OIL FILTER

the dirty oil is ofttimes accomplished by supplying air under pressure to the mass.

Other methods for purification besides filtering are the coagulating method, gravity settling, centrifugal separation and those more expensive methods in which the oil is treated chemically or is redistilled. These latter methods are rarely used.

By the method illustrated in Fig. 8, the extremely fine particles of carbon or other fine matter are united with a coagulating agent sold as "Oilite" by the manufacturers. The action is purely mechanical. The process consists in a brief but violent agitation by compressed air of the dirty oil with a solution of hot water containing the coagulant. Within a few hours after agitation, all carbonaceous matter is precipitated in the form of a layer of sludge between the oil and water. It is claimed that the oil is not affected by the coagulant and that all water and foreign matter are removed.

Settling tanks are frequently used in connection with other purification methods. Clarification by settling is a very slow process and the only advantage possessed by it is that of cheapness. Separation by this method is prolonged if the oil is disturbed by the pouring in of additional supplies of used oil during a period of operation.

(Editor's Note. Part II, which will be published in the next issue, will treat of centrifugal methods of purification and present suggestions for installation and operation of oil purifying apparatus.)

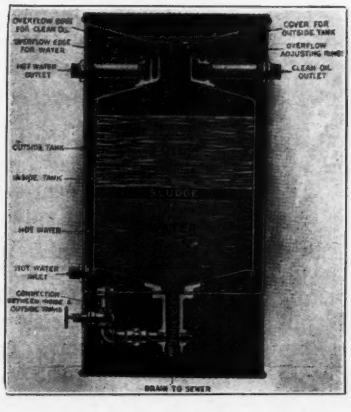
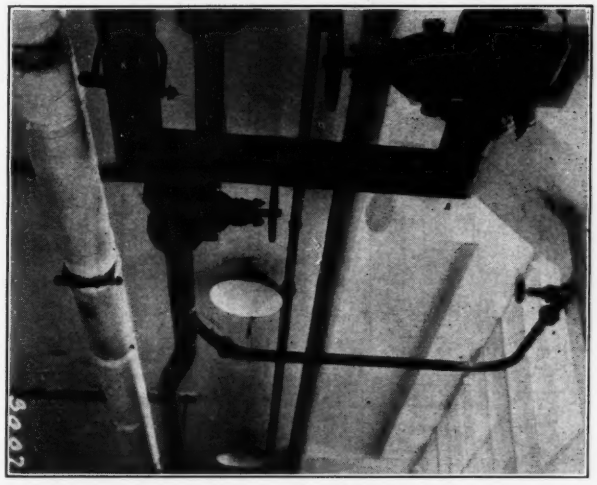


FIG. 8. DE LA VERGNE OIL RECLAIMER

Industrial Piping and the Oxwelded Joint

EXPANSIONS have taken place in many lines of business necessitating additions to old plants or erection of new units to take care of increased business. It is a significant fact that, in some of the largest construction programs lately launched, the piping contracts call for the oxwelded joint.

The increasing popularity of this type of joint can be attributed to several decided advantages claimed for it. Progressive construction engineers are recognizing it as the best modern practice on account of these salient features which are stated to be: oxwelded joints are leakproof; maintenance costs are practically nil; the oxwelded joint will last as long as the pipe itself; costly cast fittings are eliminated; any special fitting can be fabricated with cutting and welding blowpipes right on the job; cutting is made much easier and no threading



TYPICAL ALL-WELDED PIPING IN A LARGE INDUSTRIAL PLANT

is required; pipe may be purchased in 40-ft. lengths at a saving over the old method of buying many short lengths; lighter pipe may often be used, since properly made welded joints are 100 per cent efficient; a neat job results when pipe is covered with lagging; additions and changes to existing piping system may be made on short notice and at little cost.

Accompanying illustration shows a part of an all-welded piping installation in a large modern industrial plant. The work is neat and compact and in keeping with the sturdy construction of the rest of the building.

IT IS WASTEFUL to use an oil containing 8 per cent compound when 5 per cent would serve the purpose. Furthermore, the greater amount of compound of fatty materials in the original oil, the greater the percentage which may be carried over from the engines by the exhaust steam. Furthermore, the greater the fatty oil content, the more difficult will it be to effect subsequent separation to a sufficient extent to render the exhaust steam suitable as a heating medium or process work requiring a high degree of separation of oil from the exhaust steam.

Features of Recent British Oil Engines

SHOCKLESS SEATING OF VALVES AND ELIMINATION OF EXPANSION STRESSES CHARACTERIZE RECENT BRITISH DESIGNS. BY F. JOHNSTONE-TAYLOR

SOME OIL ENGINE designs recently brought out contain features that indicate trends in British practice. These relate to what may be classified as the average industrial type of engine, that is, those built in units of 100 to 500 hp. which, although not figuring to any great extent in central station practice, are being used in increasing numbers in industrial plants, pumping stations and in similar services where more or less

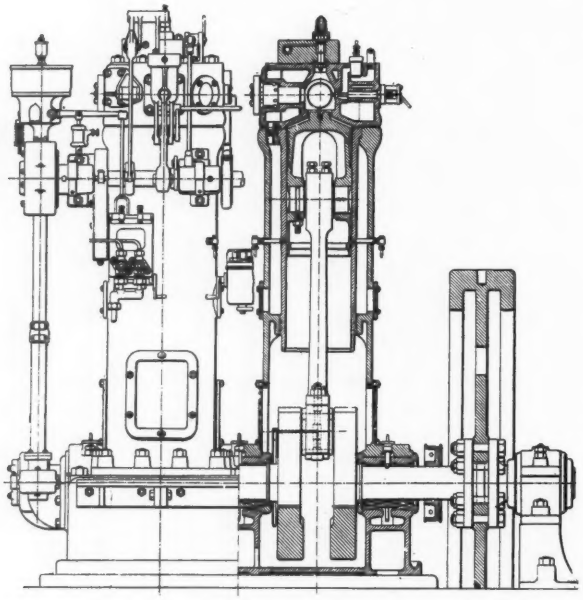


FIG. 1. DAVEY PAXMAN ENGINE HAS PLUG-SHAPED PISTON HEAD IN ORDER TO CREATE TURBULENCE

continuous operation warrants the installation of a first-class engine capable of securing high fuel economy and of being operated on the cheapest grades of oil.

TENDENCY TOWARD HIGHER SPEEDS

In addition, there is a tendency towards a type of engine, suitable for power station work, with an output of from 500 to 800 hp. but built for higher speeds than are usually associated with average Diesel practice. With one or two exceptions, these engines are of the four-stroke, airless-injection class sometimes referred to as "high-compression" and "cold-starting" oil engines. The term high compression is rather a misnomer as some well-known designs of four-stroke, airless-injection engines work with quite a moderate compression by virtue of a scientifically designed combustion chamber, while the application of external heat for starting is associated with the semi-Diesel designs.

An interesting engine of the vertical class is that of Davey Paxman, which is shown at Fig. 1. The arrangement is not unlike that associated with semi-Diesel practice, but examination of the cylinder in elevation will reveal a cam shaft, driven by a vertical lay shaft on the left, which operates the exhaust valves by a rocking lever and the inlet valve which is on the far side, by an eccentric. The valves are horizontally disposed as in the Ruston engine, while the fuel valve, centrally and vertically disposed, is also operated by a lever from the side shaft. These engines are designed for an average output of 40 hp. per cylinder at 350 r.p.m. Other points to note are the plug shaped piston head, so designed to create turbulence, and the ferrules, one which is shown in the section, which connect the water spaces in the cylinder barrel and head and thus avoid the use of jointing material.

FUEL INJECTION ACCOMPLISHED BY SPRING ACTION

Spring injection of fuel, which has proved to be successful in the Blackstone engine is a special features

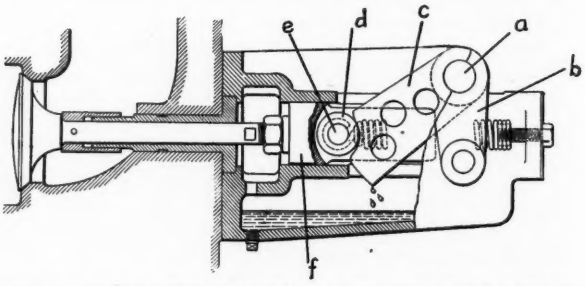


FIG. 2. SHOCKLESS SEATING OF VALVES SECURED BY SPECIAL VALVE GEAR

of the engine. With this arrangement, the fuel is not sprayed into the cylinder by the fuel pump plunger but the latter, under the control of the governor, merely functions in delivering the requisite charge of oil into a chamber behind the injection plunger where it is imprisoned for a brief period. During this period, the injection plunger moves forward and compresses the air charge to about 1000 lb. per sq. in. as determined by its spring so that the injection always takes place at a constant pressure. By this means, injection is independent of speed, cylinder pressure or pump pressure so that easy and certain starting without priming and smooth working at all speeds are assured.

RAPID VALVE MOVEMENT AND SHOCKLESS SEATING

Incorporated in this engine is also the Lentz exhaust valve system which involves a rather ingenious cam arrangement which first comes into gentle rolling contact with the sleeve and then eases the valve off its seat against the springs. The rocking shaft, a, Fig. 2, is driven by rods attached to crank b from the eccentric previously mentioned and the cam c is especially shaped, its point of application on the rolling sleeve d, which surrounds the pin e, in the guide, being practically on dead center at all times. After the release of the valve from its seat, the shape of the cam, rising abruptly, causes a rapid opening of the valve. When the cam

rocks backwards, the return stroke is similarly rapid at first, but finally becomes a slow shockless seating motion. Lever c, at every stroke, dips into an oil bath and maintains automatic lubrication.

Essential features of the Browett-Lindley engine, which has vertical valves, more generally used in large Diesel practice, are shown in Fig. 3. The construction of the cylinder head is worthy of note. The liners, which are of plain cylindrical shape, are bolted at their upper ends to the cylinder head leaving their lower ends free to expand; the water joint with the jacket being maintained by means of a rubber ring. The cylinder heads are of simple design providing ample water passages around the valve ports and free expansion ver-

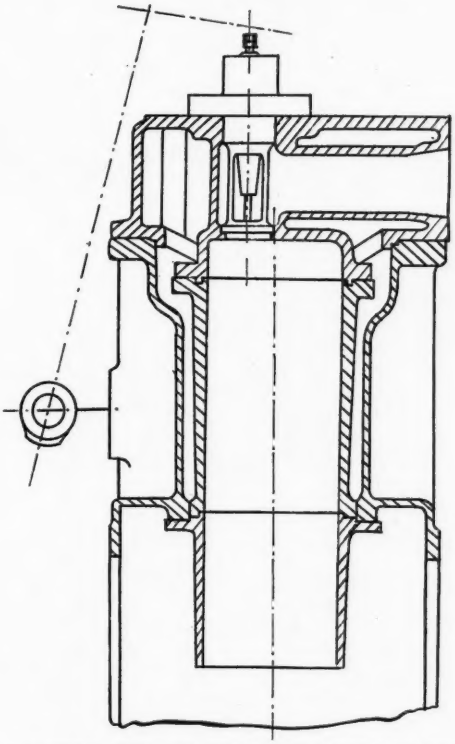


FIG. 3. LOWER END OF CYLINDER LINER IS FREE TO EXPAND IN THE BROWETT-LINDLEY ENGINE

tically. The water jacket entirely surrounds the flanged connection to the liner and there is no undue mass of metal at this point to cause stresses due to unequal expansion and contraction. The pistons are made in two parts and arranged for easy removal through the side doors of the crank case. Four-cylinder engines with cylinders 12 in. by 16 in. are rated at 200 hp. at 330 r.p.m.

An engine designed for somewhat higher powers is that of Bellis & Morcom which is shown in section at Fig. 4. Although only of moderate power, this is regarded as being well suited to central station work, having cylinders 15½ in. by 17 in. each developing 100 hp. at 300 r.p.m. The maximum possible use is made of cast iron in the construction of this engine which was a massive heavily cross-ribbed crank case in place of the more usual A frames. This piston, too, is of cast iron and is oil-cooled in the head by a system of knuckle pipes.

Breech Construction Provides Excellent Cooling

Horizontal four-stroke, airless-injection engines represent a type of industrial power unit which is almost standard in Great Britain, as seen in the Ruston, Crossley, Tangye and other makes, and has proven to be very successful. In the recently designed Crossley-Premier

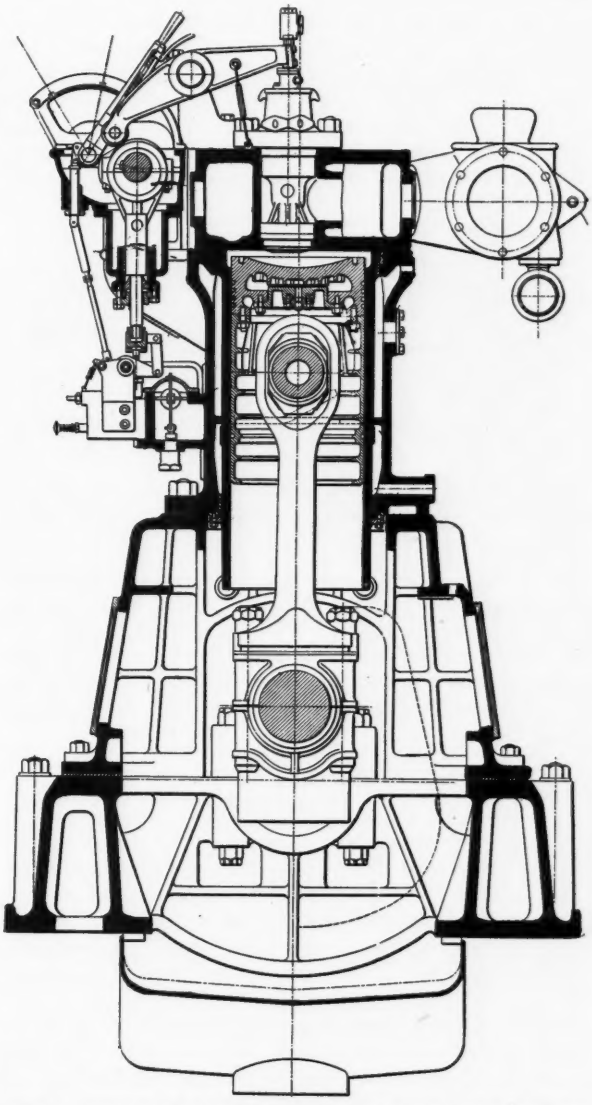


FIG. 4. BELLIS & MARCOM ENGINE HAS HEAVILY RIBBED CRANKCASE

engine, the salient features of the multi-cylinder, horizontal gas engines of the Premier Co. are in evidence as seen in the section shown in Fig. 5. It is a relatively slow speed engine usually built with four cylinders and rated at 100 hp. per cylinder. Special interest attaches to the breech construction where exceptional provision is made for cooling and to freedom from expansion stresses due to heat which the horizontal design undoubtedly facilitates. The liner and breech-end are made integral in one casting so that the liner joint is eliminated.

While rather massive for the power developed as compared with a vertical engine of higher speed, special advantage can be claimed for this design because of its

great accessibility. Pistons can be taken out, cleaned and replaced quite easily within an hour, valve springs can be replaced while the engine is running because due to duplicate construction, one may function during the short period necessary to replace the other while the removal of the spray valve and the simple disk which forms the end cover, gives complete access to the cooling surfaces.

There appears to be a field in central station work where incidentally some submarine engines have been installed but without any great success, for the high speed Diesel engine of fairly large output and compact design which originated with the submarine engine. The Fraser & Chalmers unit of this type, shown in Fig. 6, has cylinders 21½ in. by 22 in. and is rated at 200 hp.

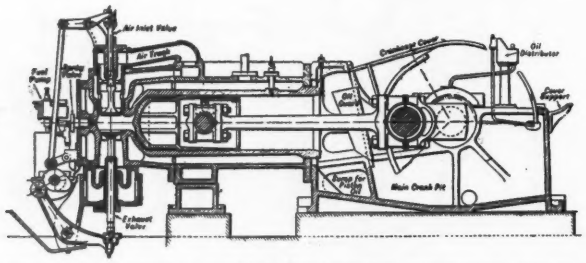


FIG. 5. FREEDOM FROM EXPANSION STRESSES CHARACTERIZES THE HORIZONTAL ENGINE OF THE PREMIER CO.

per cylinder at 300 r.p.m. Four and six-cylinder units are being built so that the latter could be classed as quite a powerful unit. Air blast injection is employed so that operation is on the full Diesel cycle, although with its trunk pistons and exceeding low height of 12 ft., considerable departure from orthodox design is apparent.

Bending Stresses Eliminated by Cylinder Construction

Attention is especially directed to the special design of the top part of the cylinder liner where the gas tight joint is made. Between the cylinder head a, which consists of a slab of steel and the hot gases of combustion is interposed a steel "combustion plate" b, which is secured by studs to the cylinder head and is ribbed on its upper surface to provide effective distribution of the cooling water over those surfaces which are in direct contact with the combustion temperatures. The gas joint is directly above the supporting shoulder of the liner. By this means bending stresses are eliminated, an important matter when the joint has to withstand a cylinder pressure of 90 t. The screwing down load on the cylinder studs is approximately double that amount.

Diagonal holes, c, through which the cooling water passes up through the shoulder of the liner to the top of the combustion plate, assist in water circulation and provide an element of flexibility to the upper part of the liner enabling expansion to take place in any direction without the introduction of undue stress or liner deformation. At the lower end of the liner is a guide belt and a packed gland. The liner, which is not more than ¾ in. thick, is formed from heat-treated steel forgings in order to withstand the lapping action of the aluminum pistons. The latter will be seen to be formed in two parts. In the upper part, a deeply dished crown is cored out in the form of an oil cooled chamber and it is secured to the lower part by means of tee-headed bolts, the oil being supplied through a link system; but the exhaust valves, constructed of special heat resisting metal, are uncooled, thus increasing the simplicity of the construction.

High Velocity of Cooling Water

Mention might also be made of the high velocity water circulation, which is provided across the top of the combustion plate in the vicinity of the exhaust valve, and of the guiding of the latter in a cast-iron sleeve

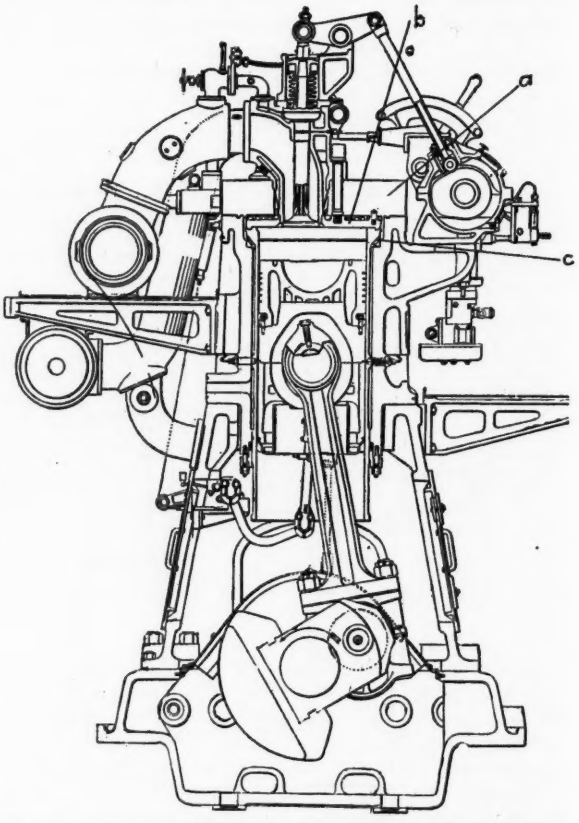


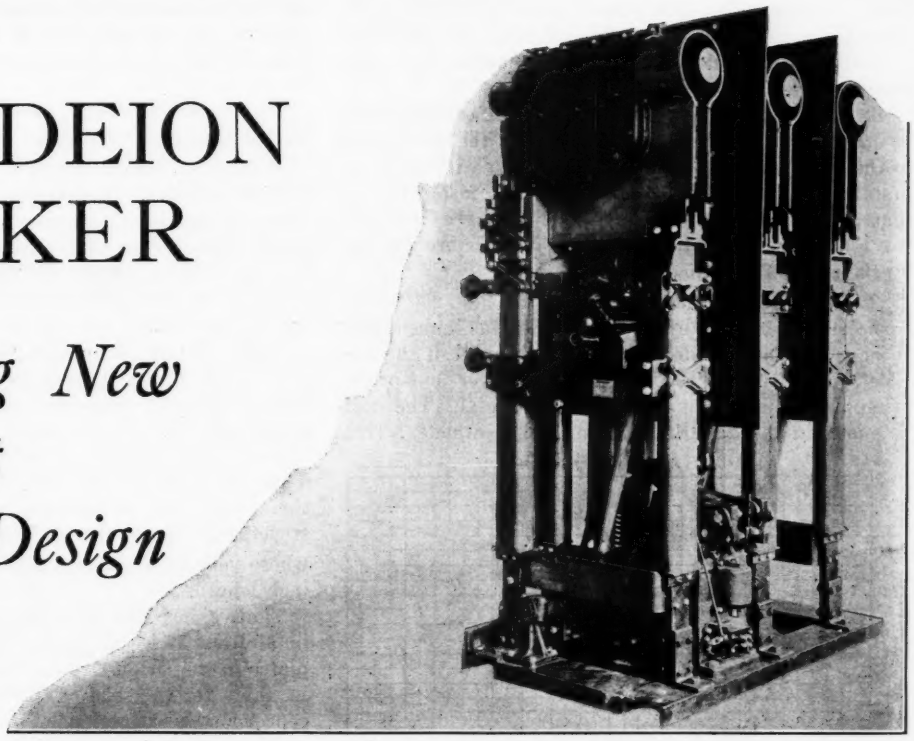
FIG. 6. BENDING STRESSES AT THE GAS JOINT OF THE CYLINDER LINER ARE ELIMINATED IN THE FRASER AND CHALMERS DESIGN

with a relatively large clearance combined with a deflector to prevent the escape of exhaust gases at this point and the use of double springs to facilitate replacement. The air compressor is of the four-cylinder, three-stage "quadruplex" type driven direct from the crankshaft and located at the end of the engine opposite to the flywheel.

JANUARY SALES of mechanical stokers, as reported to the Department of Commerce by the 10 leading manufacturers in the industry, totaled 97 stokers installed under boilers of 42,392 hp., as compared with 102 stokers under 49,212 hp. in December and 75 stokers under 26,572 hp. in January, 1928. Of the total of 97 stokers for January, 1929, 36 stokers were installed under fire tube boilers of 5835-hp. capacity and 61 stokers under water tube boilers of 36,557-hp. capacity.

THE DEION BREAKER

Something New in Circuit Breaker Design



IT IS NOT often that we are privileged to present an article about something as radically new and with such interesting possibilities as the Deion circuit breaker. This is a new circuit breaker for use on alternating circuits employing a new principle of arc control which gives promise of wide application on alternating current power systems.

The question of building a reliable circuit breaker for use on a.c. circuits has always been a difficult problem to the electrical engineer. Early in the game it was found that when an electric circuit was broken in air, the opening was accompanied by considerable fireworks and much noise. Usually, too, after the commotion had subsided, the principal parts of the circuit breaker had vanished—had evaporated, so to speak, and the next thing in order was to call out the repair gang. This was not only annoying but exceedingly uneconomical.

It was natural, in seeking a way out of the difficulty, to attempt to smother the arc by submerging it in a bath of oil—oil was known to be a good insulator. This was a practical solution of the problem which served very well, but it involved certain complications which the electrical engineers accepted only with reluctance. For as the capacity of systems increased, the physical size of circuit breakers became quite formidable. Nevertheless, the oil circuit breaker did its work much better than any other type of switch developed and today, although it has its limitations, it is a highly developed, highly perfected device.

Now, however, comes Dr. Joseph Slepian, of the Westinghouse Electric & Mfg. Co., with a new circuit breaker incorporating a novel principle of operation. The details of this breaker, its principle of operation, its constructional features and test results were presented recently in a series of three papers delivered at the Winter Convention of the American Institute of Electrical Engineers.

In the development of this breaker, Dr. Slepian and his associates started with a long and detailed study of the electric arc which accompanies the opening of any electric circuit. This arc was recognized not merely as a destructive phenomenon but as an important element in the functioning of any circuit breaker.

It was as a result of this study of the nature and behavior of the electric arc, that the Deion circuit breaker was developed. For the first time the function of the arc in the operation of circuit interrupting devices were clearly recognized, and steps were taken immediately to effect its practical application. The result, obtained in the Deion circuit breaker seem to indicate the correctness of Dr. Slepian's reasoning.

Nature and Properties of the Arc

The switching of electric power circuits calls for elements which, subject to control, shall function sometimes as good electrical conductors and at other times as good insulators, and which can change from one state to the other in a fraction of a second. So far, the only materials found which can meet these requirements are gases, and arcs in air, and arcs in the vapors and decomposition products of oil are serving regularly to control power circuits. The arc plays a very necessary and desirable part in the opening of a switch, in fact, if the arc did not occur spontaneously on separating the contacts, it would have been necessary for us to discover or invent it or its equivalent for the purpose of circuit interruption.

Realizing the importance of the arc, Dr. Slepian

and his associates made a careful study of the arc, particularly with a view of trying to find out what happens when the change-over occurs from the state of conductor to the state of insulator, that is, the moment of extinction of the arc.

In this study, it was found that in the extinguishing of an arc, that is, in its conversion from the conducting to the nonconducting state, the ability to withstand the first few hundred volts recovered almost instantly, but that later increments of dielectric strength were recovered at a very much slower rate. This is brought out by the curve shown in Fig. 1.

Theory and experiment indicate the first 250 v. are borne almost entirely by a thin layer of gas immediately adjacent to the cathode or negative terminal of the arc. Electrons in the gas readily leave this layer, but others to replace them cannot enter from the metal. The positive ions in the gas discharge into the cathode. Thus

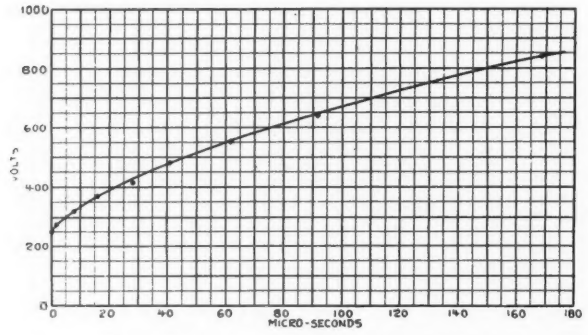


FIG. 1. RECOVERY OF DIELECTRIC STRENGTH OF ARC SPACE OF SHORT ARC

Voltage required to reignite arc immediately after current in an a. c. circuit has passed through zero. Arc in air at atmospheric pressure.

this layer of gas near the cathode is deionized exceedingly rapidly.

Why an Arc Is Conducting

It must be understood that an arc is electrically conducting because it contains ions, that is, atoms which have been split up, so to speak, into positive and negatively charge units. These "charged" elements are the carriers of electricity which give the arc its conducting properties. The arc can be rendered non-conducting by actually removing the ions or by permitting the positive and negative elements to recombine so as to form neutral atoms.

In the thin layer of gas next to the cathode, the ions probably are actually removed. The positive charges combine with negative charges on the cathode while the negative charges are drawn in the opposite direction by the force of the electrostatic field. In the layers of gas farther away from the arc terminals, deionization takes place largely by recombination of the opposite charges and the action is much slower. This accounts for the subsequent slow further growth of dielectric strength, after the attainment of the first 250 v.

It is evident then that it is the slow rate of recombination of the ions in the arc space away from the electrodes which limits the applicability of the arc in air for interrupting high voltages. In endeavoring to overcome this inherent limitation of the arc, an obvious suggestion was to reduce as far as possible the arc space remote from the cathode, and so far as possible cause all the arc to play in a space close to the cathode; in other words, to use a large number of short arcs in series. This is what is done in the Deion circuit breaker.

Principle of the Deion Breaker

As developed at present, the Deion breaker consists of a stack of copper plates 1/16 in. thick separated by 1/16-in. spacers. The arc which is drawn on contacts below this structure is blown by a magnetic field into the stack. The arc is thus broken into short arcs in series, each of 1/16 in. length. There are thus in each inch of structure 8 cathodes with their 8 immediately adjacent rapidly deionizing gas layers.

Immediately after the current passes through its zero value in its normal cycle each cathode layer is almost instantly deionized, and acquires the ability to withstand 250 v. much faster than any practical power circuit of corresponding voltage can supply the 250 v. Thus, the voltage necessary to reignite the arcs after the current zero is eight times 250 or 2000 v. per in. of structure. Hence the structure will interrupt circuits whose voltage is not over $2000/\sqrt{2}$ or 1414 v. r.m.s. per inch length.

This seems like an extremely high voltage for arcs in air, but it by no means represents the limit. The plates in the Deion circuit breaker have been made 1/16 in. thick for the sake of thermal capacity but so far as concerns the extinction of the arc, the plates could be 1/32 in. thick or 1/64 in. thick. The spacing between the plates was made 1/16 in. so as to permit free motion of the arc. Experiments show, however, that 1/32 in. spacing still leaves sufficiently free motion of the arc. If a breaker were made using these last figures, there would be 21.3 plates per inch, and therefore the structure would interrupt 3760 v. r.m.s. per inch.

In the present Deion breaker, the circuit volts per plate is kept very much less than the theoretical limit of 175 v. r.m.s. would permit, in fact it is less than 130 v. This was done not only to secure a factor of safety but also because of the fact that when a voltage is impressed across a series of plates, the voltage does not divide equally between the various plates, but tends to concentrate among end plates as shown in Fig. 2A.

The Static Shield

It was due to this unequal voltage distribution that is was necessary in the course of development, to devise a static shield which would effect a more uniform distribution. This was finally accomplished with the result that the voltage distribution between a stack of plates instead of being as shown in Fig. 2A was as shown in Fig. 2B.

The use of this shield, it will be obvious, is very necessary. In Fig. 3 are shown the potential distribution curves of the shielded and unshielded stacks. On this diagram a perfectly uniform potential distribution is indicated by the curve A, which naturally is a straight line. The departure from uniform distribution as obtained by the unshielded stack is great as shown by the curve B. Curve C gives the voltage distributions with the shielded stack. This curve, it will be noted, follows the ideal distribution more closely. As a matter of fact, this curve was obtained with the first static shield made. Later designs give still better results.

From the diagram, Fig. 2, it would seem that the average volts per gap at which the unshielded stack would operate in a Deion breaker would be in the ratio of 9 to 1 so that if 176 v. r.m.s. is the theoretical limit for a single gap, 176 ÷ 9.1 or 19.4 volts per gap would be the limit for the unshielded stack, or about 1375 v. for a stack of 72 plates. Similarly for the shielded stack, 176/2.6 or 67.8 v. r.m.s. would be the limiting average voltage per gap and 4810 v. would be the limit for the whole stack.

Actually, however, the unshielded stack was found by test to be good for nearly 6000 v. r.m.s. and the shielded stack for more than 10,000 v.

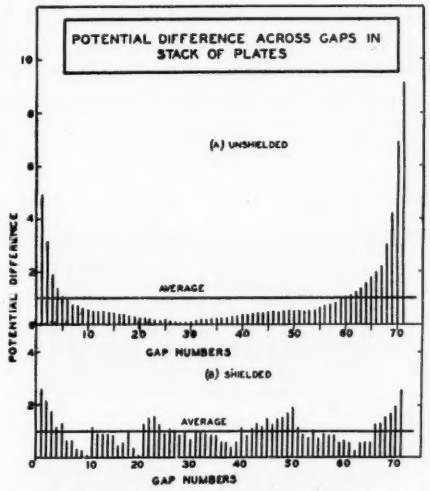


FIG. 2. POTENTIAL DIFFERENCE ACROSS GAPS IN STACK OF PLATES

To explain these results, it is necessary to examine more in detail the mechanism of reignition of an arc immediately following a current zero. The action has to do with the formation of a glow discharge between two electrodes. A glow is a discharge requiring several hundred volts at its cathode as compared with 10 or 20 v. required by an arc. It seems probable that when an arc space is broken down by the application of more than 250 v. immediately following a current zero, the current is first passed in some form of discharge like a glow and only after a little time does the discharge break down into an arc. The time to change from the glow form to the arc will be very short if considerable current (that is several amperes) flows in the glow and will probably be only a few hundredths of a microsecond. If, however, the current flowing in the glow is limited (that is a fraction of an ampere) the time for change from glow to arc may be many microseconds.

In the Deion breaker, immediately after the current zero, the voltage tending to reignite the arc in the stack of plates rises at a rate depending on the nature of the circuit in which the breaker is working. In a fast practical power circuit, this reignition voltage may reach its maximum value in about one microsecond. During this period of rising reignition voltage, the overstressed gaps in the deion stack may be subjected to more than 250 v., even though the average volts per gap impressed is much less than 250. These gaps then pass current, but the magnitude of this current is limited to that of the charging current of the remainder of the structure where the gaps are not broken down. If this charging current is small, the discharge in the overstressed gaps will remain in the glow form, and will require in each gap a voltage of not less than 250 v. The overstressed gaps then continue to hold more than the average voltage per gaps so that the remaining gaps are not overstressed and the arcs in the structure do not reignite.

If the charging current is too high, however, the discharge in an overstressed gap may break down from the glow form to an arc. It then takes only 20 v., which is much less than the average volts per gap and thus causes more voltage to be thrown upon the remaining gaps. This may make the next overstressed gap break down into an arc with further raising of the voltage on the remaining gaps. This process may continue until all the remaining gaps are overstressed, and then reignition of all the arcs in the stack takes place.

Cold Electrode Arcs

As already explained, the efficacy of the Deion breaker resides in having all parts of the arc in close vicinity to deionizing surfaces. This is accomplished in the heavy current switch by blowing the arc into a stack of closely spaced plates so that no part of an arc is farther than 1/16 in. from a deionizing cathode. If the short arcs in this structure stood still for the duration of one-half cycle, 1/120 sec., the structure would quickly be destroyed by the welding together of some plates and the burning of holes through others.

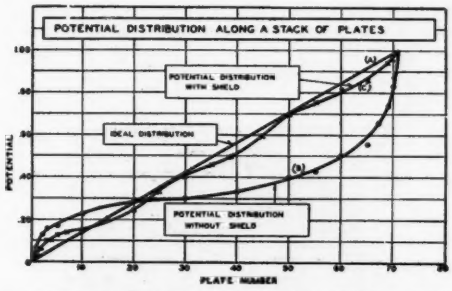


FIG. 3. POTENTIAL DISTRIBUTION ALONG A STACK OF PLATES

At the time this work was begun, it was believed that the cathode of an arc was necessarily at a very high temperature. In fact, the theory generally accepted then required thermionic emission of electrons from the cathode for the maintenance of the arc, and for most metals the temperature for so intense a thermionic emission is far above the boiling point.

In the course of this work, however, it was forced upon the author's attention that sometimes arcs were obtained which did not have a hot cathode. Therefore, although it required considerable courage to take a stand opposite to that espoused by so many eminent authorities, the thermionic emission theory of the Cathode of an arc was abandoned, and arcs with cold cathodes were accepted as possible. Experiment soon showed that by moving the terminals of the arc sufficiently rapidly over the electrode surfaces, melting could be avoided even for very heavy currents. Arcs of more than 20,000 amp. have thus been carried on copper electrodes for more than 0.01 sec. with only slight oxidation of the electrodes.

A theory of the cathode of an arc was also developed based on the hypothesis that the metal itself is not necessarily at a temperature sufficient for thermionic emission but that a layer of gas or vapor immediately adjacent to the cathode is so intensely ionized, perhaps in virtue of very high temperature, that the arc current can be carried to the cathode by positive ions only.

In the Deion breaker, the melting of the electrodes is prevented by causing the arc terminals to move very

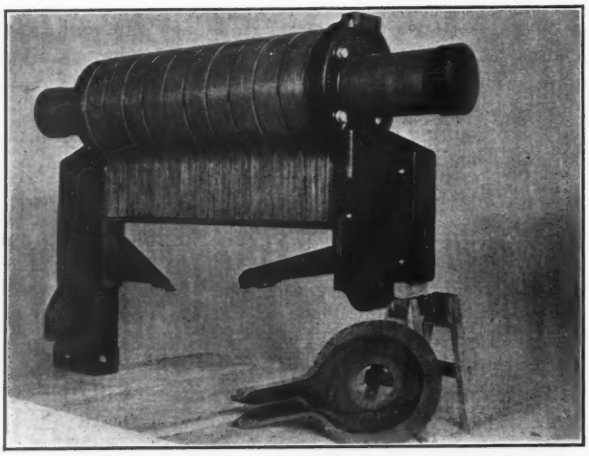


FIG. 4. DEIONIZING CHAMBER WITH BLOW-IN MAGNET AND ELECTROSTATIC SHIELD REMOVED TO SHOW GENERAL ARRANGEMENT OF THE PLATES, RADIAL FIELD COILS AND VENTS

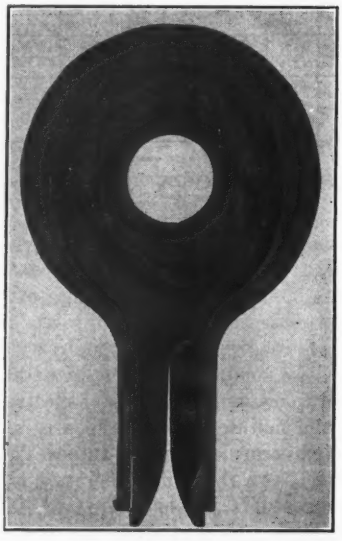


FIG. 5. PLATE FROM DEIONIZING CHAMBER WITH INSULATING SPACERS IN POSITION, SHOWING THE TRAILS LEFT BY THE ARC TERMINALS IN MOVING OVER THE RUNWAY

rapidly over the electrode surface by means of a magnetic field. The first experiments were carried out with a stack of long straight plates as the deionizing structure. It was found, however, that the velocity of the arc terminals necessary to prevent melting of the electrodes was so great that for 10,000 amp. plates more than ten feet long would be necessary. These would be prohibitive from the standpoint of size for most applications and would require too expensive a magnetic field structure.

This difficulty was surmounted by causing the arcs moving with high velocity to retrace over and over again an annular path. On adopting this expedient a very important new advantage was obtained. The deionizing structure became an almost completely closed structure. The arc, when once driven in, could not get out again, and had to stay in until its extinction at the end of the half cycle. Thus the danger of the arc getting across live parts outside the switch and causing short circuits was practically eliminated.

General Construction

In the illustration at the head of this article is shown a view of a 15-kv. Deion breaker, made up of three single-pole units, each consisting of a deionizing chamber, an arc drawing mechanism with main contacts for carrying load current and a controlling mechanism. The deionizing chamber consists essentially of a stack

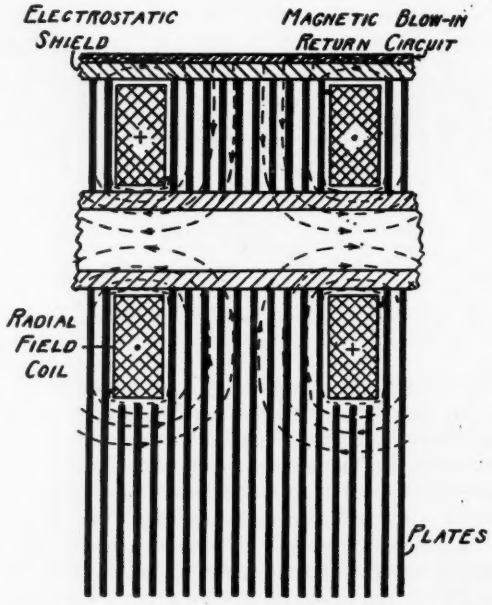


FIG. 6. SCHEMATIC RELATIONSHIP OF PLATES AND RADIAL FIELD COILS FOR THE DEIONIZING CHAMBER, SHOWING THE MANNER IN WHICH THE RADIAL FIELD IS PRODUCED

of these copper plates spaced a short distance apart to form a series of gaps, the general arrangement being shown in Fig. 4. In each of these gaps are placed insulating spacers which enclose arc runways, each having a straight entering portion and a circular portion. One of these plates with its insulating spacers in position is shown in Fig. 5. Approximately 130 v. r.m.s. has been found to be a safe working voltage for each gap, so a large number is required for a 15-kv. breaker. These gaps are divided into groups and separated by coils connected in such a way that the magnetic fields of adjacent coils are in opposition, which causes the flux to be diverted radially through the gaps as shown in Fig. 6. The terminals of these radial field coils are so connected that they are automatically inserted in the circuit by the arc itself as it moves into the deionizing chamber. This is accomplished by short plates placed directly under

the radial field coils for the purpose of developing a high voltage on the section of arc subtended by the coils.

A blowout magnet of conventional design, while adequate for small deionizing chambers working at low voltages, did not develop a suitable blow-in field for the larger chambers necessary for 15-kv. service. A blow-in magnet of entirely new design was, accordingly, constructed for this breaker. In this magnet, the coils are wound so as to cover the entire space in which the arc is drawn and extended. The cores on which these coils are wound are fabricated of iron and insulating material in such manner that the field in the air gap is concentrated at the necessary points for rapid movement of the arc into the deionizing chamber. The cores and coils are supported by a laminated return circuit passing over the top of the deionizing chamber. This return circuit acts also as a partial return path for the flux of the radial field coils previously referred to, and as a shield against stray magnetic fields. The general appearance of this magnet may be seen by referring to Fig. 1.

The electrostatic shield used to effect uniform voltage distribution between the gaps, also serves as insulation between the deionizing chamber and the blow in magnet. This shield has layers of tin foil imbedded in it shaped and located so that each plate is forced to assume its proper electrostatic potential. The deionizing chamber, the blow-in magnet and the electrostatic shield form a complete unit which is hinged at the rear support so that it may be rotated upward for inspection.

Operation

The theory of the Deion circuit breaker deals only with an arc after it has been drawn and is in no way connected with the method of securing a tripping impulse. Inasmuch as standard closing mechanisms are used to operate this breaker, tripping may be obtained in any conventional manner applicable to modern breakers of other types. The operation of the breaker up to the time of drawing the arc is similar to that of conventional circuit interrupters drawing an arc in air.

Path of the Arc

When the arc is drawn on the arcing contacts, the action of the blow-in field moves its terminals onto stationary arc horns very quickly, permitting the movable arcing contact to continue its opening stroke independent of the motion of the arc. The speed of arcing contact separation is sufficient to insure adequate break distance of the contacts at the time of interruption. To prevent possible retardation due to movement of the arc into a closed chamber, vents are provided at each end. As shown in Fig. 4, parallel copper plates spaced quite close together are placed in the vents to confine the arc and at the same time permit passage of air from the chamber. As the arc travels up the horns past the vents, it impinges on the metal plates of the deionizing chamber. As illustrated in Fig. 5, the lower end of these plates have a tapered slot. When a number of these plates are stacked together, these slots form a groove, roughly V-shaped, into which the arc is forced. The contour of the groove is such that as the arc moves upward, its cross section is decreased and the current density increased, with a corresponding increase in arc voltage. When a sufficiently high arc voltage is reached, the arc strikes to the plates, forming a series of short arcs which move into the circular portion of the plates under the influence of the blow-in field.

The portion of the groove below each radial field coil is made up of short plates introducing several gaps across the terminals of the coil. The increase in arc voltage resulting from the presence of several short series arcs in parallel with the coil insures sufficient voltage across its terminals to deflect the current into the more inductive path of the coil winding. Under the influence of the radial fields, the short arcs trace an annular path around the circular portion of the plates. This motion continues until a zero of current is reached, at which time deionization prevents further flow of current. Under these conditions, arcs have been found to move around this path more than 15 times in ½ cycle, with a velocity several times that of sound.

These breakers have been tested both in the laboratory and in the field. Currents as high as 25,800 amp. have been interrupted without signs of distress on the part of the breakers.

While, so far, the performance of the Deion circuit breakers has been limited to test conditions, the results obtained indicate that all the expected advantages will be obtained in regular operating service. It appears that the limitations of this breaker are more capable of definite determination than those of oil circuit breakers.

Considered as a whole, the development of the Deion breaker is an admirable piece of work and serves to show how by going back to fundamentals, practical solution of difficult problems may result.

The Power Corporation of New York, operating the Northern New York Utilities, Inc., Light and Power Building, Watertown, N. Y., affiliated with the St. Regis Paper Co., same address, has preliminary plans in progress for the construction of a new hydroelectric power plant on the Raquette River, near South Colton, vicinity of Potsdam, N. Y. It is planned to proceed with the project early in the spring. The work will include the construction of a power dam, 50 ft. high and 1000 ft. long; the power house will be arranged for an initial unit of 12,800 hp., with provision for installation of additional generating equipment at a later date, to increase this output by 26,000 hp., making a total rating of 38,400 hp. for the plant. A transmission line will be constructed to connect with other power lines of the company in this district, and a considerable portion of the output will be used for paper mill operation. The entire enterprise is expected to cost close to $500,000.

At the recent British Industries Fair, held at Birmingham, was shown a sleeve-valve type, heavy-oil, airless injection engine in a three-cylinder model. Each cylinder develops 50 hp. at 900 r.p.m. This is the first of this type to be placed on the market and has a single sleeve of steel moved vertically and oscillated horizontally by a rocker from a lay shaft to control admission of air and exhaust of burned gases. Other details are similar to those for heavy-oil engines of the usual type. Starting is by compressed air. Fuel consumption is 0.4 per brake horsepower-hour and lubricating oil 1 pint per hour for 150 hp.

Electricity---What It Is and How It Acts*

PART XX. HOW THE THERMIONIC EMISSION OF ELECTRONS EXPLAINS THE EDISON EFFECT. RECTIFICATION. FORCES INVOLVED IN ELECTRON EMISSION. BY A. W. KRAMER

FROM THE EXPLANATION of the principles involved in the emission of electrons from a hot cathode, it is evident that this phenomenon serves to explain the Edison effect referred to at the beginning of the preceding article.[1] It will be recalled that when the plate in Edison's lamp was connected to the positive terminal of the filament, the galvanometer in the circuit

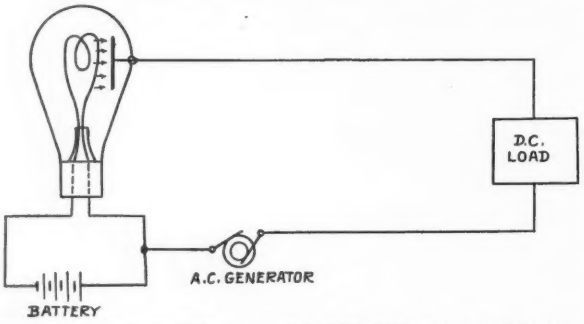


FIG. 1. SHOWING HOW A TUBE RECTIFIES AN ALTERATING CURRENT

The thermionic principle permits the current to flow from the filament to the plate but not from the plate to the filament. Hence, an alternating current tending to flow in the circuit will have one-half of the cycle suppressed, causing a pulsating direct current to flow in the circuit.

indicated an electric current. This current, we know now, is the result of electron emission from the hot filament of the lamp. When the plate was connected to the positive terminal of the filament battery, the plate became charged positively and an electrostatic field was established in the space between the filament and the plate so that any electrons in this space would, under the action of this field, tend to move to the positive plate. Thus there is established a space current which will be indicated by a galvanometer connected into the pate circuit. So what remained an insoluble mystery to Edison in the early eighties is now perfectly clear because of our knowledge of the electron.

If the plate in the bulb, instead of being connected to the positive terminal of the battery is connected to the negative terminal, the plate will assume the same potential as the filament so that there will be no electrostatic field to draw electrons to it. Under these conditions practically no electrons are carried to the plate and no current flows.

HOW A VACUUM TUBE RECTIFIES ALTERNATING CURRENT

A device of this kind incorporating a hot filament or cathode and a cold anode or positively charged plate, therefore possesses the property of what is known in electrical engineering as unilateral conduction. In other words, such a device is capable of conducting current if it flows in one direction but not in the reverse direction. The action is very much like that in a non-return valve, and as such, a tube of this kind will serve as a rectifier of alternating current.

Suppose that the device is connected into an alternating current circuit in the manner shown in Fig. 1. Since alternating potential is impressed across the space between the filament and plate, an alternating electrostatic field will be set up between these elements, the frequency of which will be equal to the frequency produced by the generator. The potential on the plate will vary continually from positive to negative and back again. Whenever the plate is charged positively, current will flow from the filament to the plate, but when the plate polarity changes to negative in the succeeding half of the cycle, the electrons are all driven back into the filament and no current flows. Thus the introduction of the tube in the alternating current circuit has the effect of suppressing the negative half of the cycle as shown in Fig. 2. The resulting effect is a pulsating direct current as shown at B. The positive loop is somewhat distorted because of the way in which the resistance of the tube varies with the current. A pulsating current of this character can be used for charging storage batteries and in this field, such vacuum tube rectifiers have received great application. The Tungar and Rectigors battery chargers so well known to radio fans employ rectifying elements of this type.

This rectifying principle of the two-element or two-electrode vacuum tube was first recognized in 1905 by

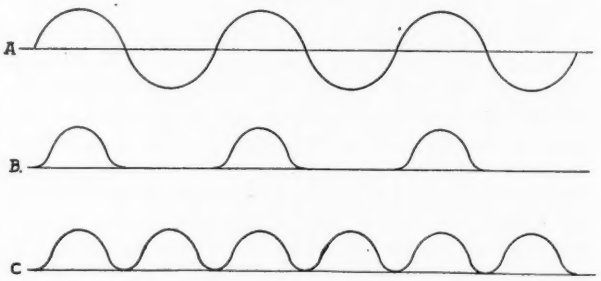


FIG. 2. WAVE DIAGRAMS SHOWING EFFECT OF HALF AND FULL WAVE RECTIFICATION

A showing a simple alternating current wave. B shows the effect of a single rectifying tube in the circuit. C shows full wave rectification, obtained by the use of two tubes connected as shown in Fig. 3.

John A. Fleming in England.[2] At that time, Fleming was engaged in the development of a system of wireless telegraphy and he obtained a patent on the use of the vacuum tube as a detector of high frequency electrical oscillations. This patent[3] became one of the fundamental patents in vacuum tube development.

The arrangement described above, merely suppresses one-half of the alternating-current wave. The effect is the same that would be obtained by merely opening and closing a switch in an alternating-current circuit so that the circuit was completed only when the current flowed, say, in the positive direction. By an arrangement of two tubes or by means of a modified form of tube employing two plates, both halves of the cycle may be utilized. The arrangement for accomplishing this is

*All rights reserved
[1]Part XIX March 1, 1929 issue, p. 301.
[2]J. A. Fleming, Proc. Royal Society, Jan., 1905.
[3]U. S. Patent, 803,684.

shown in Fig. 3. Although two tubes are used, only one tube is in use at one time. A little study of the diagram will show that while the plate of one tube is charged positively the plate in the other tube is charged negatively; thus, while one tube is conducting current, the other is inactive. The instantaneous directions of current in the circuit for two successive halves of the cycle are shown in Fig. 4. With an arrangement of this kind

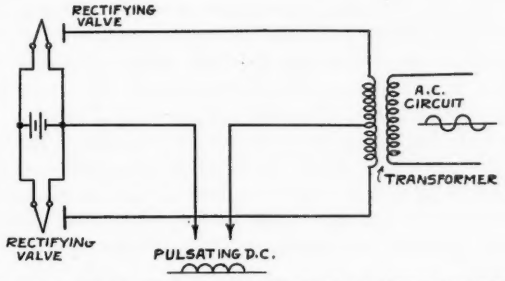


FIG. 3. A FULL WAVE RECTIFYING CIRCUIT UTILIZING TWO TUBES

the lower loop of the alternating-current wave of Fig. 2A is transposed above the zero line so as to give the pulsating current shown in Fig. 2C.

The development of the two-electrode tube was one of tremendous importance and it has led to other developments which are of far-reaching effect in the civilized world; but before we discuss these subsequent

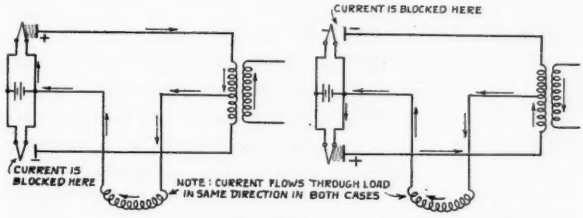


FIG. 4. INSTANTANEOUS CURRENT DIRECTIONS FOR TWO SUCCESSIVE HALF WAVES OF AN ALTERNATING CURRENT

developments, it will be of interest to study further the principles involved in the mechanism of the vacuum tube.

Effect of Plate Potential Upon Electron Emission

In the preceding article,[4] it was shown that the number of electrons emitted from the filament was a function of the filament temperature. Therefore, if the temperature of the filament is maintained constant, the number of electron emitted per sec. will likewise be constant.

It was shown also, that the number of electrons drawn to the positively charged plate was dependent upon the value of the positive charge. Thus with the filament temperature held at a constant value, as the potential on the plate is slowly increased from zero, the number of electrons drawn over to the plate also slowly increases. If the increase of plate potential is continued, however, a value of plate voltage will be reached, eventually, under which all of the electrons emitted from the hot metal, will be attracted to the plate. When this value is reached, any further increase of plate potential will cause no further increase in plate current. This is known as the saturation current. If the value of the plate current be plotted against plate potential, a curve will be obtained having the general shape shown in Fig. 5.

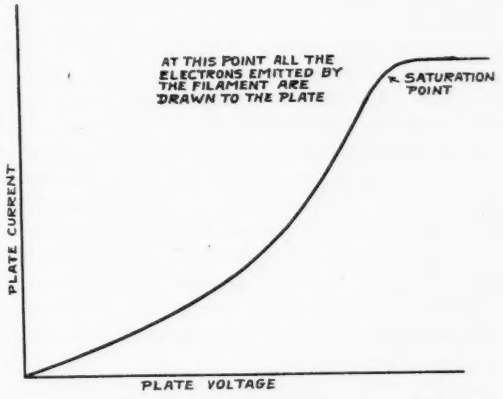

AT THIS POINT ALL THE ELECTRONS EMITTED BY THE FILAMENT ARE DRAWN TO THE PLATE
SATURATION POINT
PLATE CURRENT
PLATE VOLTAGE

FIG. 5. VARIATION OF PLATE CURRENT WITH VARIATION IN PLATE VOLTAGE

Suppose, however, that we increase the temperature of the filament. Increasing the temperature increases the molecular agitation in the metal and results in an increase in the number of emitted electrons. Now, if we again increase the plate potential we will observe another increase in plate current, until a new saturation point is reached at which all of the emitted electrons are drawn over to the plate.

So, for each filament temperature, there is a definite saturation current which is obtained when the plate potential removes the electrons at the same rate at which they are evaporated from the filament.

How an Electron Escapes from a Hot Metal

It has been stated that the electrons escape from the solid metal of a hot filament by virtue of their kinetic

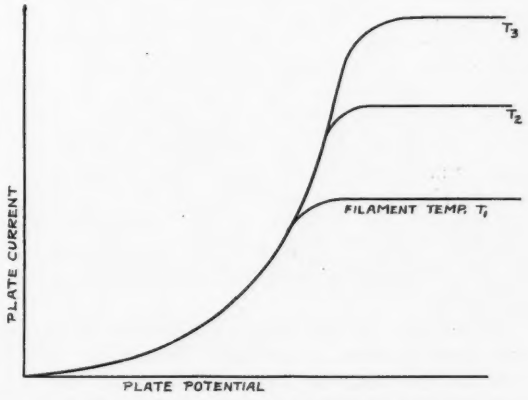


FIG. 6. SATURATION CURRENTS FOR VARIOUS FILAMENT TEMPERATURES

energy. This implies that an electron must overcome a certain resistance or must do a certain amount of work in order to make its escape from the solid body.

At low temperatures, the kinetic energy of the electrons is insufficient to enable them to break through the surface tension of the metal but as the temperature is raised the molecular agitation of the molecules is in-

[4]Part XIX Mar. 1, 1929 issue, p. 303.

creased, causing an increase also in the agitation of the electrons.

Now it will be evident that, given a certain amount of kinetic energy, an electron very near the surface of the metal will have a better chance to escape than one farther away from the surface, since the latter will have to use up a certain proportion of its store of energy in first reaching the surface. An electron which has had to travel some distance say to reach the surface of the metal, may find upon reaching the surface that practically all of its store of energy has been spent so that if it does emerge it will be drawn back into the filament almost immediately. Another electron endowed originally with the same amount of energy, however, but located very near the surface will have a considerable store of energy left after breaking through the surface which will carry it a considerable distance away from the filament. It is for this reason that the distribution of electrons in the space surrounding a hot metal de-

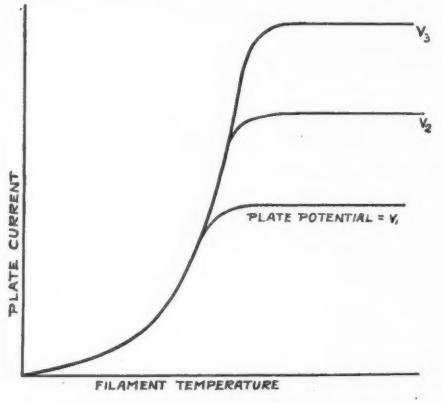


FIG. 7. PLATE CURRENT VARIATION WITH INCREASE OF FILAMENT CURRENT UNDER VARIOUS PLATE VOLTAGES

creases in density as the distance from the hot surface is increased. Only those electrons having the highest velocities and located (at the start of their flight) comparatively close to the surface can reach any distance beyond the surface. Naturally, as the temperature is raised, the electrons travel to greater distances but at any time, regardless of the temperature, the electron density will always be very much greater near the surface of the metal than at some distance from it. In certain experiments by Morecroft,[4] he found that in a tungsten filament tube operating at normal operating temperature only 1/8000 of the electrons emitted reached a distance 0.15 cm. from the hot filament. Most of them perhaps never went farther than 0.001 cm. from the surface.

The amount of work which an electron must do to escape from a metal is perfectly definite for different metals and its value for any metal is called the "evaporation constant" of that metal. It is usually expressed in terms of the number of volts (the equivalent volts) through which an electron must drop in order to acquire sufficient kinetic energy to do this work.[5]

[4]J. H. Morecroft. Principles of Radio Communication, p. 439.

[5]The evaporation constant and the equivalent volts are connected by the relation $\emptyset = \frac{w}{e}$ where $\emptyset$ = the equivalent volts, that is the number of volts through which the electron must drop, w = the evaporation constant and e = the charge on the electron (4.774×10^{-10} electrostatic units.)

The value of this factor, that is the number of volts through which an electron must fall in order to escape from the surface of a metal, is an exceedingly important one in the study of thermionics since it determines the amount of electron current that can be obtained from any particular type of cathode at any temperature. Its value varies for different substances, being considerably lower with elements such as thorium, lithium, and sodium, than for such metals as tungsten and platinum. For this reason, the filaments of modern vacuum tubes are often coated with barium oxide or are made of a mixture of tungsten and thorium. Such filaments provide a much larger electron emission at a certain temperature than would a plain tungsten or platinum filament at that same temperature. It is highly desirable to have cathodes with a low electron affinity as this property is called since the power that must be dissipated in the heating of the cathode to obtain a definite plate current decreases as the electron affinity decreases.

From this, it must be evident that the actual value of saturation current for a definite temperature of cathode and for a definite value of plate potential is dependent upon the character of the cathode. The actual saturation current I_s for a given filament temperature T in a tube having a perfect vacuum is given by the equation[6]

$$I_s = A\sqrt{T}\, e^{-\frac{b}{T}}$$

in which I_s = the current of emission per sq. cm. of hot metal.

T = absolute temperature of the hot metal, C.

b = latent heat of evaporation of electrons = 105,000.

a = a constant, depending upon the physical structure of the elements.

Effect of Varying Filament Temperature

Now, let us return to our study of the actual electron emission in the vacuum tube. Instead of varying the plate potential as was done in the above instance, let us vary the filament temperature while maintaining the plate potential constant at a particular value. When the filament is cold there can be no current flowing in the plate circuit since no electrons are being liberated from the filament. Suppose, now, that the filament is gradually heated. As soon as the temperature reaches a point where electrons are emitted, a current will begin to flow in the plate circuit which will increase as the temperature is raised higher. As the electrons are evaporated out of the filament they are drawn to the plate, and are absorbed by the latter. At any instant,

[6]This equation, it may be noted by those familiar with thermodynamic theory, is very similar to the equation which gives the number of atoms liberated during evaporation of a liquid. This is as follows:

$$N = A\sqrt{T}\, e^{-\frac{a}{2T}}$$

where N = number of atoms evaporating per second, per sq. cm. of surface.

T = Absolute temperature, C.

a = latent heat of evaporation.

A = a constant.

Thus it can be seen that the similarity between the evaporation of electron from hot metals and the evaporation of ordinary liquids extends even to the mathematical computations.

therefore, there will be a certain number of electrons in the space between the filament and the plate. As the temperature of the filament is still further increased, the electrons will be emitted at a rate faster than they can be absorbed by the plate, and as a consequence, the number of electrons in the space between the filament and the plate at a particular instant will be increased. In other words, the density of the electron cloud in the space will be increased.

Being composed entirely of negative charges, this electron cloud as a whole will exert in the space between the filament and the plate an effect opposite to that of the plate. This is known as the space charge.

If the filament temperature is still further increased this space charge will gain in effect until, finally, a condition of equilibrium will be reached, the space charge overcoming the effect of the positive plate charge. When this condition is reached, the space charge will repel the emitted electrons, forcing them back to the filament. Beyond this point, no further increase in filament temperature will result in any further increase of plate current. If a greater plate current is desired, it will be necessary to increase the plate potential.

If the plate potential is increased, a further increase in filament temperature will again result in an increase of plate current until finally a new condition of equilibrium is reached. Thus, for every value of plate potential there is a corresponding value of filament temperature beyond which no further increase in plate current can be secured. The curves representing this effect are shown in Fig. 7.

Thus, it is seen that the operation of a tube of this kind say for the purpose of rectifying an alternating current, depends primarily upon two things, the plate potential and the filament temperature. There are other factors which, in practical devices, have a great effect on the operation but they may here be considered secondary factors. The amount of gas in the tube, for instance, has a distinct effect which in the practical application of the tube are of great value, but this, notwithstanding its importance, may be considered a secondary effect. The two things to be kept in mind are, the electrons are evaporated from the filament by virtue of its temperature, and they are attracted to the plate because of the value of the plate potential.

Speed of Electron Emission

Before we close, it may be of interest to know something about the speed at which the electrons leave the surface of a hot metal. In the case of tungsten, it is known from certain experiments that an electron must fall through a potential difference of about 4 volts before it gains sufficient kinetic energy to overcome the restraining force at the surface of the metal.

Since we know the electric charge on the electron and its mass, it is a simple matter to determine the amount of kinetic energy gained during such a fall and from this, knowing the mass, the velocity at the end of its fall can be determined readily.[7]

Without attempting to follow through the calculations, it can be shown that if an electron falls through a difference of potential of one volt, it will attain a velocity of approximately 5×10^7 cm. per sec., that is about 311 miles per sec.

Since the surface tension with tungsten is such that a drop of 4 v. is necessary for an electron to break through, it can be shown that under these conditions an electron must have a velocity of 1×10^8 cm. per sec. or some 623 miles per sec. Of course, as has already been pointed out, if an electron approaches the surface of the metal from the inside at this speed, it will not break through, since part of its store of energy will be used in overcoming the resistance offered to its passage by the atoms and other electrons in the metal. If, under this velocity, they do manage to get through, their velocity upon emerging is spent and they at once fall back into the metal. So in order to attain any appreciable distance from the filament, the velocity of the electrons must be considerably greater than 623 miles per sec. Most of the electrons that manage to get through the surface (assuming that they are not influenced by any extraneous field) do not travel far before falling back into the metal.

So it is seen that these tiny electrons travel with a great deal of speed—much faster than anything we are familiar with in ordinary matters. Here, in the vacuum tube, for the first time we can study their action apart from ordinary matter and it is because of this that the study of vacuum tube phenomena has shed so much light upon the fundamental theories of electricity and matter.

It will pay us well to study their action further, and in succeeding articles we will follow them in their flight across the space between the filament and the plate.

There is a growing tendency in German steam-operated electric power stations to adopt Diesel-engine sets for use in emergencies and in periods of unusual loads. A 15,000-hp. Diesel engine generator has been in use at the power station in Hamburg for some years, while now two of 11,700 hp. are being installed at the Henningsdorf power station of the Markische Elektricitatswerk Gesellschaft. Each of the engines which have been built by the Augsburg-Nurnberg Maschinenfabrik, of Augsburg, comprises ten cylinders of 600 mm. bore and 900 r.p.m. stroke, the normal speed being 215 r.p.m. Each engine will be coupled to a Siemens-Schuckert 6000-v. generator.

It is strange that, despite the great development of hydroelectric power stations in the country, Switzerland should not possess any institute or laboratory devoted to hydraulic research and experiments. This lack is now being filled, however, by the establishment of an hydraulic research laboratory in connection with the Federal Technical High School in Zurich at a cost of about $240,000, part of which is being provided by Swiss concerns interested in the manufacture of plant for hydraulic and hydroelectric installations.

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[7] Since the potential energy lost is equal to the kinetic energy gained.

$$V e = \tfrac{1}{2} m v^2$$

in which V = the potential difference through which the electron has fallen in absolute electrostatic units; e = the charge on the electron (4.774×10^{-10}); m = the mass of the electron, and v = the final velocity of the electron.

From the above equation, by transposition we get

$$v^2 = 2V\frac{e}{m}.$$

The value of $\frac{e}{m} = 5.3 \times 10^{17}$ electrostatic units.

Truing Commutators

By W. E. Warner

ALTHOUGH COMMUTATORS in service can be kept in good condition by the periodic use of abrasive cloth and hand truing stones, in course of time the wear becomes so great that it becomes necessary to remachine them to remove those errors which cannot be removed by hand methods. It is impossible to remove a great amount of metal by hand; it is also impossible to remove eccentricity, owing to the abrasive not being rigidly held.

Eccentricity, or the tendency for a commutator to wear egg shape, is often very troublesome, as it causes considerable vibration of the brushgear and throwing of the brushes from the commutator surface and renders the commutator out of balance. It is important that this is removed and machining must be very carefully done or the eccentricity will be reproduced although perhaps to a lesser degree.

A commutator may be either turned or ground. While turning is satisfactory, grinding is usually preferable provided it is properly done and proper equipment used. Far less metal is removed by grinding and the face of each segment is ground to its true curvature which is not always attained in turning, due to twist and spring; it is also possible to do the final grinding at the operating speed of the commutator which will prevent errors due to any distortion which may occur at this speed.

Machining may be done either by removing the armature and commutator from its bearings and turning or grinding up in a lathe or by means of special attachments it may be done while the armature rotates in its own bearings.

Turning in a Lathe

When turning in a lathe, care should be taken that the commutator runs absolutely true and that the lathe is free from any defects such as excessive play, etc., which would cause the turned surface not to be true. When running in its own bearings, the turning or grinding attachment should be very rigidly fixed so that no spring is possible and the clearance in the bearings should not be excessive. It is advisable to take only light cuts as heavy cuts, particularly if the commutator is badly out of true, tend to reproduce eccentricity. The final cuts should be very light and followed by a final polishing, say with a little crocus powder on a soft cloth. Before commencing to machine, be sure that the commutator is absolutely tight.

When the commutator is hot after running, the end nuts should all be tried with a spanner to see whether movement is possible; if these nuts are tight, then the commutator is tight. The spaces between the commutator risers should be stopped up as well as possible with canvas to prevent any dust being carried inside the armature; any other coils where dust would be harmful should also be covered.

If turning is decided on, the tool used should be keen and ground as for cutting copper, some operators recommend setting the tool point slightly below the centre line to reduce the liability to dig in, but success is mostly dependent on experience and careful turning. The final finishing can of course be done by grinding if required.

If done by grinding a medium soft grinding wheel should be used, run at the speed recommended by the wheel makers. The wheel should be kept sharp and only light cuts taken, the final cuts being taken with the commutator rotating at its normal operating speed. When finished, the whole armature should be blown out with compressed air, and the armature tested electrially with a megger to detect any possible electrical faults which may have developed.

Submission of Papers for World Engineering Conference at Tokyo

Details of the plans for the coming Power Conference and Engineering Congress to be held this fall in Tokyo, Japan, were published on page 220 of the February 1, 1929 issue of Power Plant Engineering, prepared from data sent out by the American Committee of the World Engineering Congress. The article stated that copies of the papers to be presented at this meeting should be sent direct to the secretaries at Tokyo.

A further statement regarding such papers has just been received from the American Committee, as follows: "Papers may be sent directly to Japan but there is more assurance that they will be included in the official American programs if they are sent to the chairmen of the respective American Committees for transmission. Calvin W. Rice is chairman of the American Papers Committee for the Tokyo Sectional Meeting of the World Power Conference and Dugald C. Jackson is chairman of the American Technical Program Committee for the World Engineering Congress, both of whom should be addressed at 29 West 39th St., New York."

Measure authorizing establishment of rural utility districts, modeled after the organization of drainage districts, has been introduced in the Iowa legislature, being presented in the house and the senate the same day. It provides for incorporation and operation of rural electric light, heat and power distribution lines and telephone systems, giving each district the right to incur indebtedness and levy and collect taxes for retirement of principal and payment of interest thereon. The bill does not permit purchase of electric plants but only the obtaining of power from commercial or other municipal organizations and an election is required before any proposed district can function. Advocates point out that it will make possible immediate electrification of communities which can not now afford the cost of maintaining lines connecting with electric energy sources.

There are two classes of thermometers which operate on the pressure principle. The first is the vapor pressure type, which is partially filled with a volatile liquid such as ether, sulphur, dioxide, ethyl chloride, or methyl chloride; the other, liquid pressure type, which is completely filled with a liquid or gas, such as, mercury, alcohol or nitrogen. Instruments of the first type have scales that are made up of non-uniform divisions while instruments of the second type have uniformly divided scales.

A New Method of Cold Storage Plastering

AN INTERESTING DEVELOPMENT in cold storage building construction was noted recently in the construction of the new ice and commercial cold storage rooms of the Oklahoma Gas & Electric Co., at Durant, Oklahoma. This consisted of indirect plastering over standard corkboard insulation. The old or usual practice of applying plaster directly over the cardboard insulated walls and ceilings in ice and storage buildings was supplanted in this instance by the method here described. The method was used to further the utility of the structure, that is to avoid crumbling, no allowance being made for whatever additional insulating value may be obtained by it.

Reference to Figs. 1 and 2 shows the details. These views show the wall plaster as applied, no ceiling plaster being required in this particular storage owing to the type of construction.

In Fig. 1, we have a horizontal section through a portion of the storage wall while Fig. 2 represents a vertical section through a portion of the floor and wall.

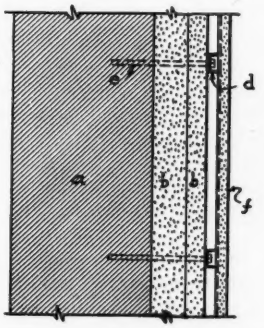


FIG. 1. SECTION THROUGH WALL SHOWING VARIOUS LAYERS OF INSULATION AND PLASTER

In both views, a and b are respectively brick walls of the storage and standard corkboard insulation applied according to standard practice. A 1½-in. standard rolled steel channel used as furring strips is indicated at d, such furring strips being placed vertically and on 3-ft. centers.

They are secured by five $\frac{1}{16}$-in. through bolts, e, set on 3-ft. centers which are installed during the period of brick laying and are for the purpose of creating a small dead air space between the room surface of the corkboard and the under side of the plaster. Standard ribbed lath, f is then applied with the ribs running horizontally and secured by tie wires to the furring channels which have one of their flanges perforated. Portland cement plaster having a hydrated lime content is then applied in the usual manner and tooled to a sand finish. To complete the accompanying drawings, h and g in Fig. 2 are the reënforced concrete storage floor and the storage floor grillage.

The underlying theory of the design is that the passage of moisture through the brick work and between the particles of corkboard will drop through the dead air space instead of forcing the plaster from the corkboard in its course of travel created by the procedure of refrigeration. All collections of moisture at the top of the floor cork protective slab c, Fig. 2, in the dead air space area will necessarily be drawn through the base of the plaster or the protective slab c and deposited on the room refrigerating elements, thus giving no cause for provision for moisture drains at the bottom of the dead air space.

In consideration of cost of this method of construction, the placing of the furring channel through bolts and fitting of the corkboard around them are the only items that involve any perceptible cost in labor. The furring channels, the ribbed lath and labor applying

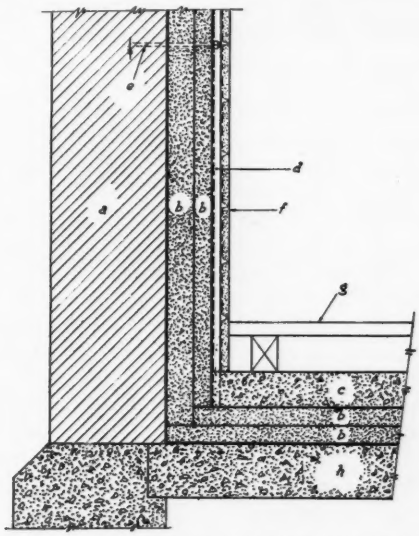


FIG. 2. SECTION THROUGH WALL AND FLOOR SHOWING CONSTRUCTION

these are items of lesser costs and neglible in high-grade work.

The design was prepared by T. F. Condon of the Byllesby Engineering & Management Corp. for the Oklahoma Gas & Electric Co. and was described in a recent number of "Byllesby Management."

SALES OF ELECTRICITY increased 23.6 per cent in 1928 over the preceding year, according to the Western United Gas and Electric Co.'s annual statement, consumers using 62,915,354 kw-hr., including residential and commercial lighting consumption of 22,118,750 kw-hr. as against 18,119,498 kw-hr. in 1927, a gain of 22 per cent; total contracted power business was 11,696 hp., a gain of 21.5 per cent. The utilities is now serving 38,747 consumers in 22 communities with estimated population of 130,000, power being sold wholesale to four municipalities which maintain their own distribution systems. During the year 620 mi. of transmission and distribution lines were added to the system, bringing the mileage to 3329 and the end of the year 38,747 meters were in use, a gain of 7109 meters, 5041 of these representing additions through acquisitions of new electric properties. Two of three modern powdered fuel furnaces now in operation in Aurora were erected during the year and numerous other improvements and extensions have been made.

SIMPLE WOUND ROTOR motors are commonly employed for elevator service involving rope speeds of from 150 to 250 ft. per min.

Dam for 200,000-Kw.

Hydroelectric Plant in S. C.

Built by Hydraulic Fill Method

GENERAL GAS & ELECTRIC CORP., New York, through its subsidiary the Lexington Water Power Co., is making steady progress on the construction of a 200,000-kw. hydroelectric development on the Saluda River, near Columbia, S. C. The earth dam, 208 ft. high, 1½ mi. long and a quarter of a mile thick at its base is nearly a third completed. This dam will contain 11,000,000 cu. yd. of earth fill and will create a lake 41 mi. long and 14 mi. wide at its widest point which will contain 750,000,000,000 gal. of water.

This dam is being constructed by the "modified hydraulic fill process." By this method two separate and distinct loose, earth-fill dams are first built across the river bed and valley from hill to hill, at a distance of about 1000 ft. from each other, thus cutting off and forming a basin of the portion of the valley between the two earth fills. These fills are raised until they are about 75 ft. high and widened until they are within about 500 ft. of each other. The area between them is then stripped of all sod and loam and all loose material removed from the exposed river bed. A core trench is next excavated, midway between the two fills and parallel to them, about 50 ft. wide and 10 ft. deep down to ledge rock or to other material through which water cannot pass.

Hydraulic Fill Forms Core of Dam

At this stage of the work, the area or basin between the two fills will be pumped full of water to a maximum depth of 25 to 30 ft. The segregation pool thus created will be maintained by pumping in enough water to take care of the evaporation and seepage. On this pool will be launched four scows, on each of which will be mounted pumping equipment for taking water from the pool to supply a giant hose or monitor, discharging 750 gal. of water per min. at a velocity of 125 ft. per sec. The streams from these monitors will be directed against the banks of the earth fills which retain the pool, washing down the fine material into the pool, where it is deposited and forms a dense heart or core for the dam. The finest material deposits at the center of the pool and coarser material deposits near the edges of the pool. The work will be carried out in such a manner that the middle sixth of the completed dam is composed of densely compacted material, of which at least 65 per cent will pass a 100-mesh screen. The coarser material left in the outer washed banks permits the water to drain slowly away from the core or heart and in time it becomes like hardened cement or a very dense clay.

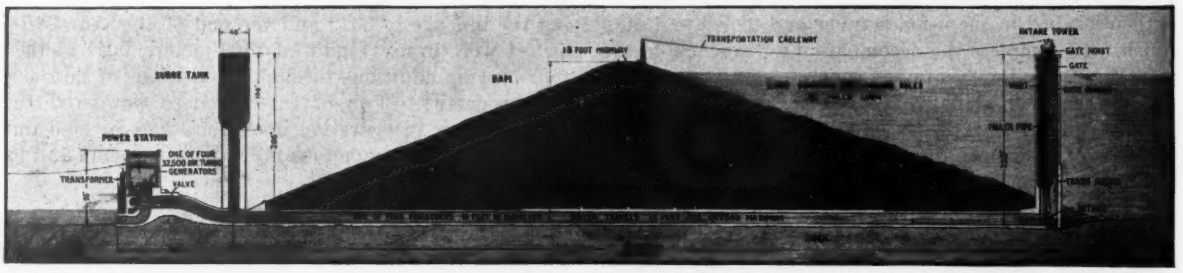
As the bottom of the pool is filled up with fine material, the outer earth fills will be raised by dumping additional loose earth, the space between these fills of course narrowing as they go higher, so as to follow in the general outline of the section of the completed dam. When within about 30 ft. of the top these sluicing operations cease as the pool becomes too small for the operations. The next 10 ft. will be built by dumping selected materials into the pool. The last 20 ft. will be built by consolidating selected materials by wetting or rolling.

Storage Lake Will Provide 250,000,000 Kw-Hr.

The lake to be created will cover an area of 53,700 acres of land, approximately 80 per cent of which must be cleared of trees and underbrush. One of the outstanding features of the development will be the tremendous storage capacity which this lake will provide. The reservoir is of such size that in the maximum drawdown expected approximately 250,000,000 kw-hr. will be obtained, exclusive of the amount of rainfall that occurs during the same period of time. Usually hydroelectric developments in the South have relatively small storages and their electrical output consequently fluctuates with stream flow. The Saluda development will overcome this situation.

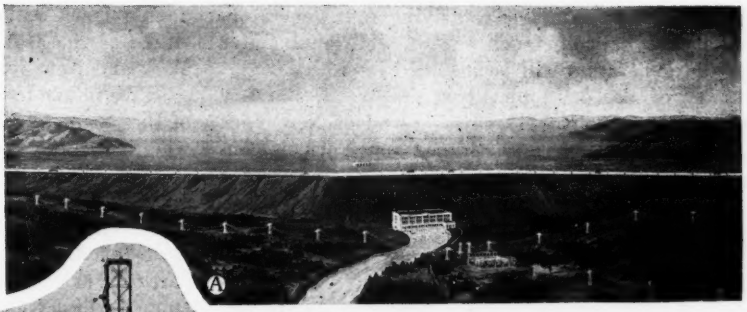
Initial Installation Will Be Four 32,500-Kw. Units

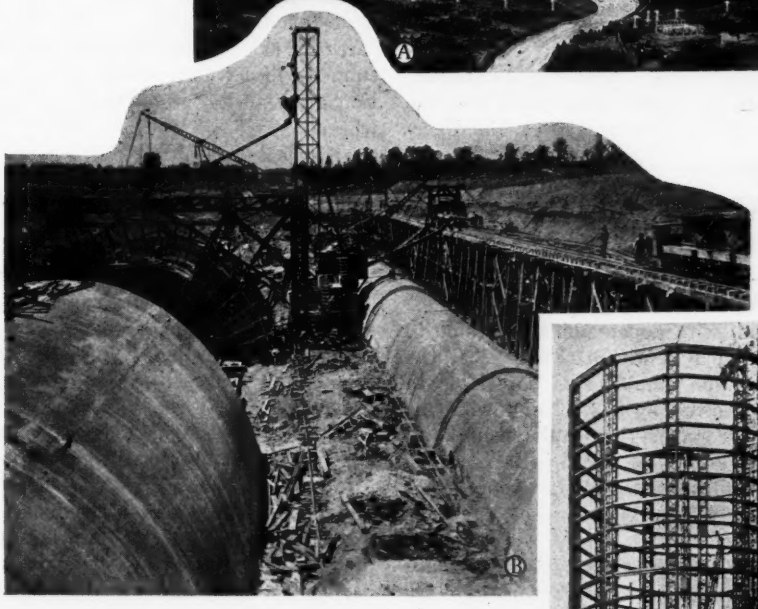
This development was started in April, 1927, and it is expected to be completed in the fall of 1930. The building of the power station, which is designed for 200,000 kw. capacity, is scheduled to be started in June,

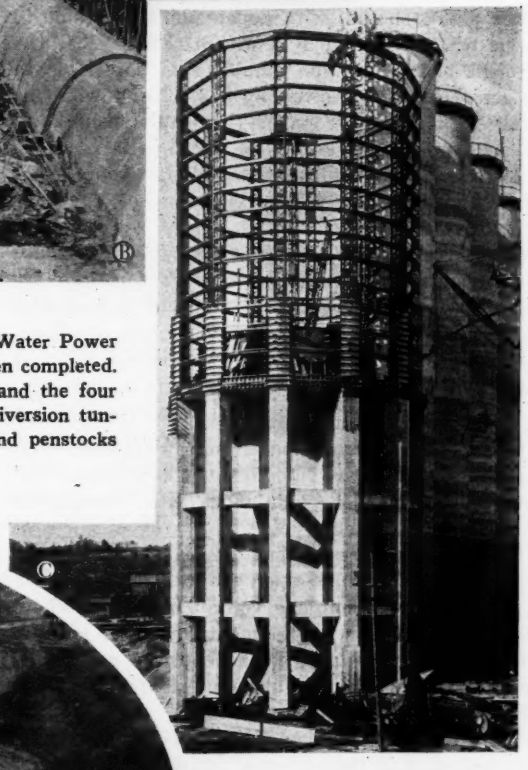


CROSS-SECTION OF COMPLETE 200,000-KW. DEVELOPMENT ON THE SALUDA RIVER

Saluda River







A—General view of 200,000-kw. development of Lexington Water Power Co. on Saluda River in South Carolina, as it will appear when completed. B—Building the 48-ft. diameter concrete diversion tunnel and the four 16-ft. concrete penstocks for the initial installation. The diversion tunnel will later contain two additional penstocks. Tunnel and penstocks pass under the dam.

C—Five intake towers under erection, four 30 ft. and one 60 ft. in diameter.

D—Section between two earth-fill dams, showing segregation pool for forming core of dam by hydraulic fill method.

1929. The initial installation will include four water wheels, 26 ft. 3 in. in diameter driving four generators of 32,500 kw. capacity each. Two additional water wheels and generators will be installed later.

Builder of the development is the W. S. Barstow & Co., Inc., New York. Murray & Flood of New York are the engineers, and A. S. Crane, New York, is consulting engineer. W. S. Barstow & Co., Inc., contracted with the Arundel Corp. of Baltimore for the construction of the conduits and dam.

Work on the big project is generally up to schedule at this time. The four 16-ft. penstocks and 48-ft. diversion tunnel were completed some weeks ago when the river was diverted from its regular channel, so that the building of the dam could further progress. The diversion tunnel is so large that it could accommodate a double track railway, being 50 per cent larger than either of the Holland vehicular tubes connecting New York and New Jersey.

Five intake towers are now under construction. Four of these towers, each 30 ft. in diameter and 223 ft. high will draw the waters of the lake into the 16-ft. penstocks. The fifth intake tower is 60 ft. outside diameter and 223 ft. high. It will admit the lake waters into the 48-ft. concrete arch conduit, which is being temporarily used for diverting the waters from the river so that earth fill can be thrown across the dam. This diversion tunnel will be used finally to accommodate two additional penstocks for operation of two additional water wheels.

Employe "Within Scope of the Employment"

By Leo T. Parker

TWO IMPORTANT reasons why the operators of power plants should, with dependability, be able to determine when an employe is within the scope of the employment are: First, an employer is not liable in damages for injuries received by a workman while he is acting without the scope of the employment; and second, an employer is not liable for injuries done to third persons by an employe who is not, when the injury is inflicted, acting within the scope of the work he is employed to do.

Present Workmen's Compensation Laws are formulated to disallow compensation to workmen, who are injured while acting without the scope of the employment, hence leading higher court decisions in which the various phases of this law have been considered, are of interest.

What Constitutes Employment

"In the course of employment," or "within the scope of the employment" are synonymous expressions but these expressions are not synonymous with "during the period of the employment."

It is important to know that the present established law on this subject is based upon the well founded principle, that, where an employe voluntarily and without necessity abandons his employment, or steps entirely aside from the line of duty, he suspends the relation of employer and employe and puts himself in the position of a stranger to his employer.

Broadly speaking, under the Compensation Laws, injuries sustained in the course of employment embrace all injuries received while the workman is engaged in furthering the business of the employer, as well as all injuries received by the workman on the premises, subject to these limitations: (1) The injury must be sustained at the usual place of employment; or, (2) the departure of the worker from the usual place of employment must not amount to an abandonment of employment or be an act wholly foreign to his usual work. In other words, if the employe is injured while attending to other than his regular duties, he is deemed not within the scope of the employment unless it be shown that it was an innocent or inconsequential departure from the line or place of duty, which caused the injury.

Moreover, the cause, the place and the time of the accident may differ from the requirements of such essentials. The cause which entitles the workman to compensation may be from defective condition of the premises, or from the operation of the employer's business, with neither negligence, contributory negligence nor willfulness as factors. The premises on which the injury is sustained must be such as are occupied by, under the control of, or the place where the master's work is usually carried on; however, the employer's premises on which the injury is sustained must ordinarily be the place where the employe's duties are usually carried on.

Injury must be received during the hours of employment. This includes hours of leisure set apart in working hours for rest, recreation, or refreshment, or attending to calls of necessity. It does not include every hour of the day; it does not include the time when the employe is off the premises, not engaged in the employer's business, nor does it include time at home preparing for work, or in coming to or after leaving the premises where the work is done.

To constitute a break in the course of employment the incident must be of a pronounced character. Although all the foregoing essentials for compensation be present, the term "course of employment" does not include: (1) injuries received while away from the actual place of employment, where the deviation or departure is wholly foreign to his duties and amounts to an abandonment of employment; (2) injuries received in the commission of an act which is in direct violation of the law; or (3) an act contrary to the positive orders of the employer.

In such cases, the cause of the accident may come within the express terms of the Compensation Act and the place and the time be in similar accord, yet no liability attach, if the accident happens through any of the three causes previously mentioned. Injuries so received do not render the employer liable for compensation.

Going To and From Work

Generally speaking, an employe is legally not within the scope of the employment when he is going to and

from work, unless the act causing the injury is done *expressly* for the purpose of serving his employer.

For example, in Langenheim vs. Industrial Commission, it was disclosed that an employe was shot and killed by a robber, while on his employer's premises, and it was contended that, inasmuch as he was, at the time of his death, on the land of the company en route to his home, his death arose from the scope of his employment, or while in the course of his employment, especially since he was on a pathway leading from the plant itself. Since, however, the injury did not result from an act intended to serve the employer, the Court held the latter not liable, and said: "It is our unanimous judgment, after learning the facts in the case at bar, that the death resulting from the revolver of a burglar, in no way connected with the company, creates a situation which is in no manner related to the employment and, therefore, the fatality does not arise in the scope of the employment and is in no manner connected therewith."

In another recent case, Harland vs. Trail, the other side of the question was considered. In this case it was disclosed that, while a workman was walking over his employer's premises on the way to work, he saw an electric wire stretched across his path. In attempting to remove it, he was killed. The Court held that the employe was acting within the scope of the employment because the act resulting in his death was done expressly for the purpose of serving his employer.

Changing Kind of Employment

If an employe leaves his regular work, by necessity, to do any act which the employer knows he is accustomed to perform, such as obtaining a drink of water, answering a call of nature, and the like, he is legally within the scope of the employment, provided he takes the shortest route to the place he is going.

Also, an employe who abandons his regular work to perform a different class of work, which is required to enable him to perform his regular duties, acts within the scope of the employment. For instance, in Southern Pacific Co. vs. Industrial Accident Commission, a night workman, who was operating a rolling mill heated the pieces of iron in a furnace before rolling them. To keep the iron in proper place for the application of the heat, rock was piled in the bottom of the furnace and the iron was placed thereon, the rock for this purpose being kept in a bin outside the rolling mill. Adjacent to this bin, but outside of the rolling mill yard, was a railroad track, used for the purpose of carrying the rock to the bin. The duty of Hunt under his employment was to take a sufficient amount of rock out of the bin and put it into the furnace, in order that the iron might be placed on the rock while it was being heated.

On the night of his death, he was engaged in his work and it was found that the rock then in the bin was too small to be suitable for the purpose but a carload of rock stood upon the track outside ready for unloading into the bin. Usually, it was not the duty of Hunt to unload this rock into the bin, or to go outside of the yard and get the rock out of the cars. On this occasion, however, he and the other man working with him, finding no suitable rock in the bin, went upon the car and threw the rock from it into the bin, preparatory to carrying it into the furnace. While so engaged, a runaway car came down the track and collided with the car containing the rock, with the result that Hunt was thrown to the ground and killed. It was also proved that the employer knew that it was customary for the workmen to obtain the rock for the purposes mentioned.

Under these circumstances, the Court held that this injury arose out of the scope of the employment, and said: "This clearly shows that the work of Hunt and his associate in getting suitable rock out of the car when none was in the bin was within the scope of his duty under his employment, as the employer, through its agent in charge of the work, had permitted that duty to be made known to Hunt."

Change at Employer's Request

When an employe changes his employment at the request of a superior, he remains within the scope of the employment.

For illustration, in Madura vs. City of New York, it was disclosed that a workman had been ordered by a foreman to run an errand pertaining to the employer's business. While on the way, a thunderstorm blew up and the employe sought shelter under a tree and was killed by lightning.

In holding the employe "within the scope of the employment" when he was killed, the Court said: "There is no question that decedent was in the course of his employment at the time he was struck. He had received specific instructions to remain at his place of employment, in order to perform certain duties when the storm had passed. Under these circumstances, he had the right to seek shelter from the storm and the effort thus to avoid its consequences did not in any manner break or suspend the relationship of employe."

Employe Changes Without Instructions

In Robert Scherer & Co. vs. Industrial Acc. Commission, however, it was disclosed that a workman having charge of an engine was requested by a fellow employe to attend to the latter's work temporarily. In doing so, the engineer was injured. The Court held that he was not entitled to compensation because the request to change occupation was *not* made by a superior. The Court said: "In order to recover compensation, the employe must, at the time of the alleged accident, be performing a service growing out of and in the course of his employment; when the servant, of his own accord and without the direction of the master, steps outside of the scope of his employment, whether on the master's business or his own, the master owes him no duty as to the dangers he encounters and is not liable for any injury received."

Also, in Schoebe vs. Schuchardt, it was shown that a workman, who was employed to operate a press, was injured while out of curiosity he attempted to operate another workman's machine. It was held that the injury did not arise out of the scope of the employment, the Court saying: "Bassman (employe) out of curiosity attempted to operate Johnson's machine, but at the first attempt his left hand was caught in the press and his fingers cut off. . . . Bassman had not been directed to operate this machine and knew that he would receive no extra compensation for whatever work he did with it. The only question presented by this record is whether the injury arose out of and in the course of Bassman's

employment. Taking the evidence in its most favorable light, with all the reasonable inferences to be drawn therefrom, we think it clear, under the authorities, that an award in this case cannot stand. . . . Where a servant voluntarily and without discretion from the master and without his acquiescence goes into hazardous work outside of his contract for hire, he puts himself beyond the protection of the master's implied undertaking and is not within the terms of the Workmen's Compensation Act. An injury to an employe while engaged in a voluntary act not accepted by or known to his employer and outside the duties for which he is employed does not arise out of his employment."

Acquiescence in Change Carries Liability

It is important to know that it has been held that where a foreman or superior knows that a workman changes positions, it is equivalent to the superior requesting the change.

In the case of Miner vs. Franklin, it was disclosed that an employe offered to render assistance to a superior, who made no reply to the offer. The employe was injured when rendering the assistance and this Court held the employe entitled to compensation, saying: "The voluntary offer of a willing servant to make himself useful in a matter not covered by any express command, when the proffered service is accepted by his superior, although not by an approval expressed in words, cannot be said, as a matter of law, to put the servant outside the limits of his employment."

An act by necessity, by which an employe changes his employment, need be of no great consequence yet the workman may legally remain in the scope of the employment.

In Malandrino vs. Southern New York Power & Ry. Corp., a workman's eye was injured by a spark from a bonfire which he had made to keep himself warm while attending to his regular duties. The Court held that the injury arose out of the employment, and said: "Much time is devoted to testimony tending to establish that there was no necessity for a fire at that time and place but there is evidence that the morning was cold and we are of the opinion that building a bonfire, to warm himself and his fellow workers . . . was not abandonment of the employment but must be accepted as fairly incidental to the work on hand."

Occasionally, an employe is injured while exposing himself to unknown dangers in order to render assistance to a superior. Since this act is for the purpose of benefiting his employer, it is deemed to be within the scope of the employment. For example, in State vs. Duluth, it was disclosed that a person hired as a foreman's keeper found an empty dynamite shell and decided that he could make it into a key for the use of his foreman. When pounding the shell into the shape of a key, it exploded seriously injurying him.

The Court held the employe entitled to compensation, saying: "We shall not attempt to formulate a definition of the phrase 'accidental injury arising out of the employment,' except to say that the accident causing the injury must arise out of work or business being done for the master either by direct or implied authority. . . . If the attempt to make a key was reasonably within the scope of his employment, the fact that, from ignorance or error of judgment, he made use of dangerous material, not provided by the master, should not necessarily exclude the conclusion that the injury arose out of the employment."

Employe Injured by Employe

Usually, an injury received by a workman who fights with another employe is not within the scope of the employment. For example, in the case of Brown vs. Jeffry Mfg. Co., on page 47, is found the following language: "It would certainly be somewhat of a surprise to the profession generally to learn that, under the statute, when one of two employes murders the other while that other is engaged at his employment, the employer is liable in damages for his death, merely because he also employs the murderer."

On the other hand, it is surprising to know that, generally, it is held that a workman who is injured, while playing with a fellow employe, is within the scope of the employment. It has been held that a workman is entitled to compensation when injured by a ball playfully thrown by another employe or when subjected to a practical joke, or when playfully pushed by a companion.

Also, in Industrial vs. Weighandt, an employe, who was on the way to his machine, was struck in the eye by a file which flew from its handle during a scuffle for its possession by two other employes. It was held in this case that the injury happened within the scope of employment.

This Court said: "The presence of the employe in a factory with other employes involves the hazard of injury from the machinery, the work itself, or the acts, negligent, or not negligent, of other employes. If an employe, while a part of that situation, receives an injury as the result of an occurrence incidental to the conduct of the business, the injury was received in the course of his employment."

Youthful or Ignorant Employes

The law is established that, as a general rule, it is the duty of one who employs young persons, over legal age, to take notice of their age and ability to understand dangers and to use ordinary care, including the giving of proper instructions, to protect them from risks which they cannot properly appreciate. It is, also, true that the same principles are applicable to the employment of inexperienced and ignorant workers.

In the absence, however, of some direct evidence to the contrary, an employer may assume that the employe has the knowledge, discretion and experience of the average workman of the same age and intelligence.

Also, it is important to know that an mployer who is aware of an employe's inexperience and ignorance, irrespective of the age of the worker, is bound to use ordinary care to instruct him with respect to the dangers of his employment. The reason for this rule of the law is that it is assumed that the employer possesses some knowledge concerning the work and its dangers that the workman, by reason of ignorance and inexperience, does not possess.

On the other hand, the servant's *alleged* lack of experience will not serve as an excuse for his ignorance where the dangerous conditions are such as should have been perfectly obvious to other persons of equal intelligence while in the exercise of due care.

It is, therefore, apparent that although an employe is commanded or urged by his employer or foreman to undertake work from which an injury results, he cannot claim indemnity or compensation where the danger was at once so obvious and so serious that no prudent man would have incurred it.

Fuel Consumption of Gas-Fired Boilers

By C. W. Stevens

MANY of the smaller industrial plants having isolated steam requirements, consider gas as fuel for boilers most economical. In natural gas districts of low-priced high-heat value gas, entire plants have their steam supplied from gas-fired boilers. Also, there are some central station public utility power plants that

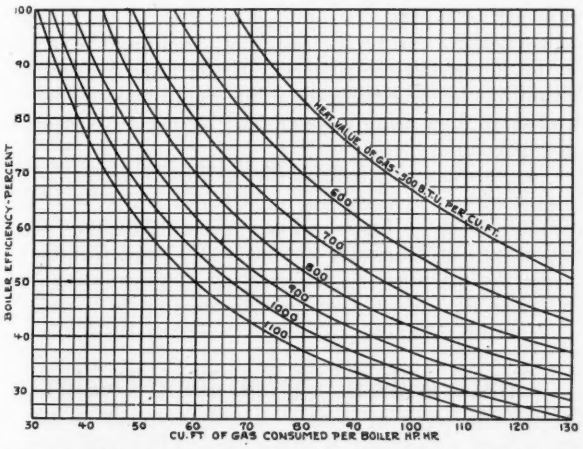


FIG. 1. GAS CONSUMPTION CALCULATED FROM BOILER EFFICIENCY AND HEAT VALUE OF GAS

utilize natural gas to some extent in their boiler furnaces.

In most of these plants that adopt gas, the actual fuel cost may be secondary to other desired features, such as labor requirements, coal and ash handling, automatic control, etc.

In order more quickly to determine the fuel costs on gas-fired boilers, the two accompanying curves are developed.

Figure 1 presents a means of determining the cubic feet of gas consumed per boiler horsepower, for various boiler efficiencies, and for various heat values of gases, to accommodate all fields, whether manufactured or natural gas.

Figure 2 gives a means for estimating the cost of fuel to fire boilers, in cents per boiler horsepower, for various fuel requirements per boiler horsepower and for gas at various rates.

From these two curves, the expected cost of using gas in steam production can quickly be determined without much calculation. For an example, a plant producing 1000 boiler horsepower has an offer to burn gas of 1000 B.t.u. per cu. ft. heat value at a rate of 30 cents per 1000 cu. ft.

Assuming an efficiency of 80 per cent for the proper utilization of the gas, from Fig. 1, we find that for 1000 B.t.u. gas, 41.5 ft. of gas will be required per boiler horsepower, of for the entire plant, 41,500 cu. ft. of gas per hour.

From Fig. 2, at 41.5 cu. ft. per boiler horsepower and a gas rate of 30 cents per 1000 cu. ft. of gas, the

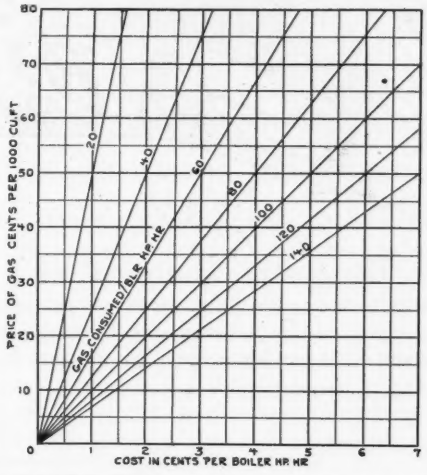


FIG. 2. KNOWING THE PRICE OF THE GAS AND THE AMOUNT CONSUMED PER BOILER HORSEPOWER-HOUR, THIS CHART GIVES THE FUEL COST OF STEAM PER HORSEPOWER-HOUR

cost per boiler horsepower will be 1¼ cents. For the entire plant, 1000 b.hp., the hourly cost will be $12.50.

In this way, fuel cost comparisons can readily be made.

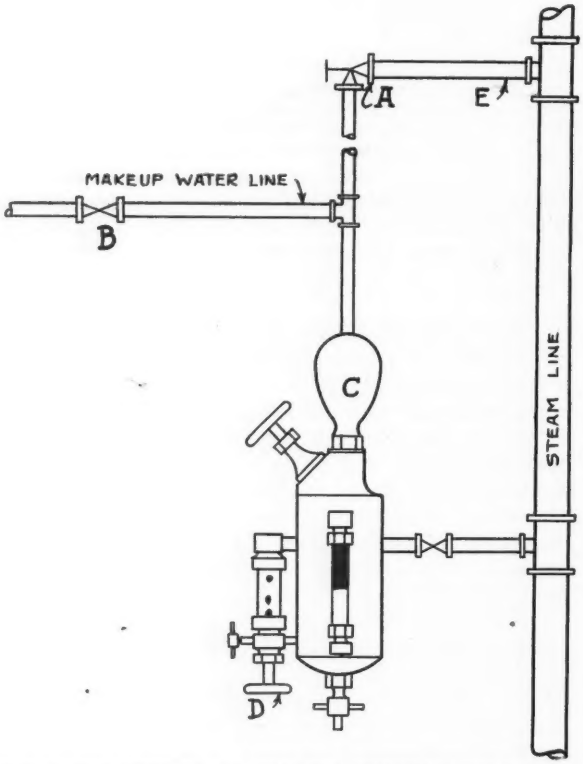
The Detroit Edison Co., Detroit, Mich., is arranging an expansion and improvement program during 1929, to cost approximately $30,000,000, including expansion in power plants, transmission lines, power substations, distributing lines and miscellaneous extensions. Of the fund noted, about $6,000,000 will be used for the completion of the new power house now under way, to be known as Delray Power Plant, No. 3, to include the installation of two 50,000 kw. steam turbo-generators, five boilers with capacity of 340,000 lb. of steam per hour. The units will be stoker-fired from one side only.

At Conners Creek a new switching station is projected to cost approximately $2,500,000; work will be completed on an outdoor switching station at Marysville, Mich., costing $325,000. At its steam heating plant on Beacon Street, Detroit, the company will carry out important betterments, estimated to cost about $350,000; a fourth boiler unit of 4145 boiler hp. rating, will be installed, and a new cooling tower completed. Approximately $5,000,000 will be utilized in extensions and improvements in underground conduit system and cable construction. Close to $2,000,000 will be used for enlarging and improving existing overhead lines. It is currently estimated that a total of about 35,000 consumers will be added to the service during this year.

At the beginning of 1927, generating capacity of all the plants in the United States was estimated at about 26,800,000 kw., a considerable increase over the capacity of the original Pearl Street Plant with its six generators and total capacity of 559.5 kw.

Hydrostatic Lubricators

LORNE B. STRADER'S IDEA described on page 72 of the January 1 issue is not new and, I believe, has little to commend its use. Water backing up into the steam



STRADER'S METHOD OF COOLING HYDROSTATIC LUBRICATOR. REPRINTED FROM PAGE 72 OF THE JANUARY 1 ISSUE

line when valve B is left open, as mentioned by Mr. Strader, can be prevented by installing a check valve in pipe E. Generally, with a hydrostatic or gravity feed lubricator connected up in the usual way, the valve D is placed permanently and seldom altered except when refilling the lubricator. It is obvious this can not be done when using Mr. Strader's plan, for should valve B leak a little or be kept open by mistake, the oil feed would be more rapid than necessary, resulting in a waste of oil. The greater the water pressure in B, the faster the oil feed is apt to be if there is any leak through the ¼-in. water feed valve. If the pressure in B is variable, the oil feed will vary also, unless constant adjustment of the right feed valve is made.

If the condenser or the lubricator has not enough capacity to supply the condensate required, the amount of condensate can be increased by extending the length or by increasing the diameter of the pipe E from the steam line to the condenser. This would be much better and safer than using a water feed having any considerable pressure.

At this date the hydrostatic or gravity feed lubricator is seldom used except in locations where it is not possible to use a force-feed automatic lubricator. This latter type of lubricator automatically stops feeding oil when the machine it is lubricating stops working and it is not dependent upon condensate for its operation.

Toronto, Canada. JAMES E. NOBLE.

Chart Aids in Piston Ring Design

IN THE ISSUE of August 1, a correspondent asked, among other questions, whether general formulas existed for the design of piston rings. There are, of course, a number of empirical rules for the design of both concentric and eccentric rings but, as a general rule, it is safer to design rings by formulas established from an analysis of the problem on first principles. Some years ago, the author had this impressed upon him at a paper mill in California where a 2000-hp. uniflow engine was giving great trouble due to wear and breakage of rings. When the dimensions of a new ring were taken and the wall pressure calculated, this was found to be at least twice too heavy and the working stress was about 2000 lb. per sq. in. higher than it should have been.

Faulty lubrication and dirty steam were also contributory to the breakages and the rectification of all the three causes cured the trouble. No piston ring, however well designed, can be expected to work for a long time in a bone dry cylinder, especially when superheated steam is used. If the ring has been properly designed and manufactured and still trouble is experienced, it is generally wise to look first at the lubrication.

The accompanying chart was first published in Power Plant Engineering for May 15, 1925, and solves three equations for the design of a ring developed by the author in "Machinery" London for November 27, 1924. The first equation is

$$t = 1.68\ D\ \sqrt{p/f_1}\ \text{ in.} \qquad (1)$$

where t = radial thickness of ring, in.

D = diameter of cylinder, in.
p = pressure of ring on cylinder wall, lb. per sq. in.
f = stress in ring in place in cylinder, lb. per sq. in.

Assuming a working stress and the desired wall pressure, (1) gives the necessary radial thickness of the ring. To determine the free gap of the finished hammered unsprung ring (2) is used

$$a = 0.000000\ 192\ \frac{D^2 f_1}{t}\ \text{in.} \quad \ldots\ldots\ldots\ldots (2)$$

where a = free gap in inches.

All the other values in (2) have, of course, already been decided on for use in (1). This completes the design of the ring and it is only necessary to see that the stress in stripping the piston is not excessive. The stress in stripping the ring over its piston is given by:

$$f_2 = f_1 \left(\frac{2 \times 3.1416\ t}{a} - 1 \right) \quad \ldots\ldots\ldots (3)$$

where f_2 is the stripping stress in lb. per sq. in. and f_1 the working stress. This latter equation may be written

$$f_2 = f_1 \times c \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where c is the value of the function in the brackets of (3) which depends on the free gap and ring thickness. The three equations were developed from those of Reinhardt (Zeitschrift des Vereines Deutscher Ingenieure, 1901) and are merely the original equations put in a more convenient shape.

The value of E, the modulus of elasticity for cast iron, is purely nominal. A value of 12,000,000 lb. per sq. in. is used in practice and has been adopted in the chart. It is the value for a fairly good cast iron and under modern manufacturing conditions may be exceeded. The modulus is reduced by hammering the ring from 10 to 15 per cent and the value adopted is that after hammering.

Northwick, Cheshire, Eng. BRIAN M. THORNTON.

Hot Conveyor Needs Special Lubricant

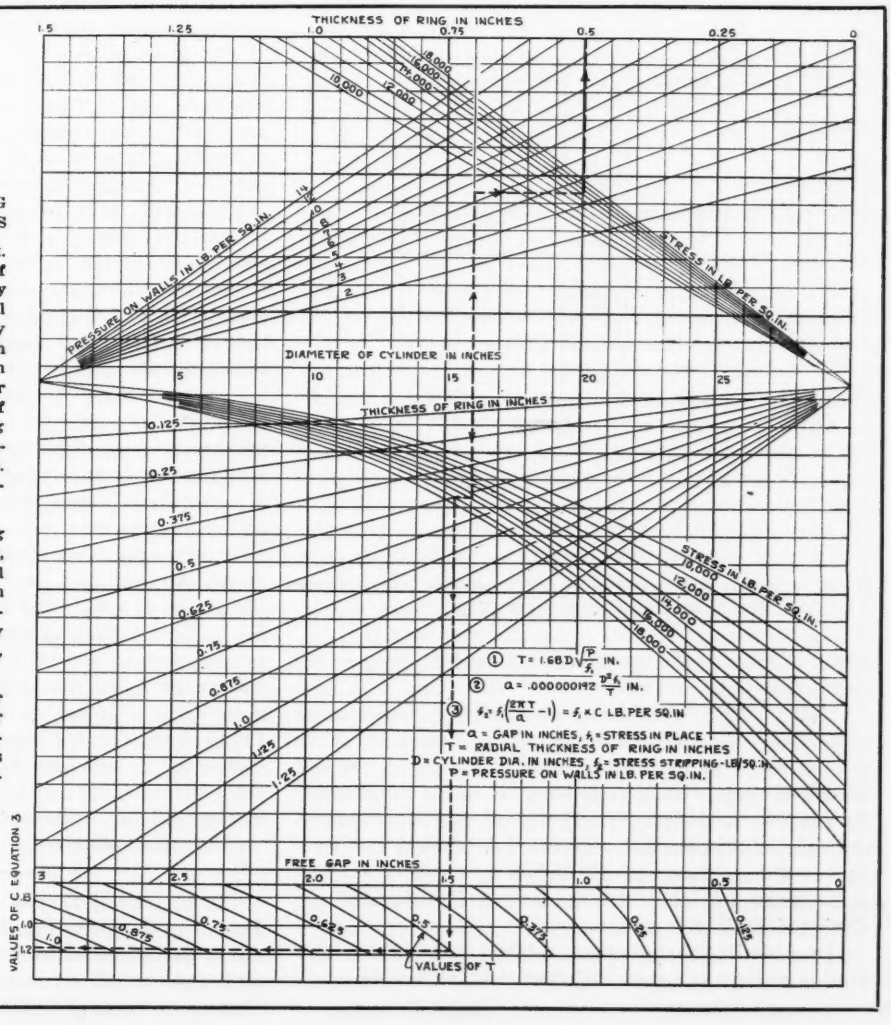
ONE OF THE MOST difficult lubricating problems confronting the engineer is that of properly lubricating conveyors that operate in heaters, kilns, core ovens, enameling ovens, etc. Chains, trolleys, bearings, and other rubbing parts used in these high temperature places must of course be lubricated. To lubricate these parts successfully over long periods of operation is particularly difficult and, so far as I know, there is no perfect oil for the purpose. The oil that is commonly used has a high flash test and a high fire test—over 600 deg. F.

CHART FOR DESIGNING CONCENTRIC PISTON RINGS

Explanation of use of chart. Starting with the diameter of the cylinder, proceed vertically upward to the desired wall pressure and then horizontally to the working stress, which should not be greater than 18,000 lb. per sq. in. but rather nearer 14,000 lb. per sq. in., if possible. From the working stress, proceed vertically upward to the ring thickness. These operations solve equation (1).

For the free gap; starting with the cylinder diameter, proceed vertically downward to the working stress, then horizontally to the ring thickness and again vertically downward to the free gap, solving equation (2).

The method of solving for the stress stripping is clear from the chart and it only remains to see that the values chosen have not given an excessive value of f_2.


THICKNESS OF RING IN INCHES
PRESSURE ON WALLS IN LB. PER SQ. IN.
STRESS IN LB. PER SQ. IN.
DIAMETER OF CYLINDER IN INCHES
THICKNESS OF RING IN INCHES
STRESS IN LB. PER SQ. IN.
① T = 1.68 D √(P/f₁) IN.
② a = .000000192 D²f₁/T IN.
③ f₂ = f₁(2πT/a − 1) = f₁ × C LB. PER SQ. IN
a = GAP IN INCHES, f₁ = STRESS IN PLACE
T = RADIAL THICKNESS OF RING IN INCHES
D = CYLINDER DIA. IN INCHES, f₂ = STRESS STRIPPING-LB/SQ. IN.
P = PRESSURE ON WALLS IN LB. PER SQ. IN.
FREE GAP IN INCHES
VALUES OF C EQUATION 3
VALUES OF T

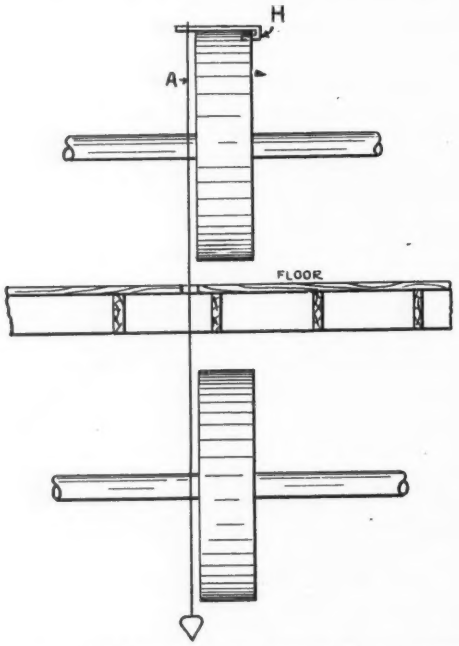
Objection to most of these oils is that, even though the temperature is no higher than 400 to 500 deg. F., considerable bituminous and tarry matter is deposited and the deposit eventually clogs up the bearings and the pins in the chain so that the parts refuse to move, resulting in damage to the mechanism.

Recent research has shown that an oil which does not possess a high flash point is better than the oils commonly used. The composition of this oil is such that when it evaporates or chars down it will leave only a small amount of residue. This residue is not of a tarry nature but is dry and fine—much like graphite. In the selection of a lubricant for hard service of this kind, it is therefore evident that it pays to select a high grade oil since, obviously, an oil that damages machinery is expensive.

Newark, N. J. W. F. SCHAPHORST.

Forged Hook Aids in Alining Pulleys

WHEN ASKED TO MOVE an iron pulley to a different location, it sometimes is not convenient to drill a hole in the pulley edge and the spot where a screw-eye in the



HOOK PLACED ON RIM OF PULLEY HOLDS ALINEMENT LINE IN DESIRED POSITION

metal ceiling would be required frequently comes between two joists.

Under these conditions, the difficulty in alining pulleys may be overcome in the following manner: Take a piece of ¼ by ½-in. iron, heat one end red hot and bend it to form a hook as shown at H in the illustration. By placing the hook over the edge of the upper pulley, the cord or thin flexible wire can be attached as shown at A. Then, using a plumb-bob, a spot can be marked and a small hole drilled in the floor and ceiling and the alining done in the usual way.

In a similar manner, this method may be used for alining pulleys lying on different sides of a wall.

Toronto, Canada. JAMES E. NOBLE.

Decomposition and Corrosion of Economizers

GRAPHITIZATION of the cast iron has been known to occur in cast-iron economizers. This consists of decomposition and corrosion of the metal which often occurs to a considerable depth. The detection of the wasted parts is rendered difficult by the fact that outwardly these parts retain much the same appearance as sound metal, the wasted metal simply becoming soft and spongy; in some cases becoming sufficiently soft to be cut by a knife. The disintegrated metal adheres to the metal which is still sound and does not fall away sufficiently to permit the wasting to be detected. The wasting is not like that of cast iron under the influence of superheated steam nor that due to the growth which occurs under repeated applications of heat but resembles more nearly the wasting of cast iron which occurs after long submergence in sea water.

Chemically, the wasted material consists of ferris and ferrous oxides in varying proportions with about 10 per cent graphite and traces of phosphorus and sulphur. The oxide and carbon become wasted away and their places taken by oxide residues. The structure of the original iron influences the susceptibility to attach; a close grained white iron has a greater resistance than grey cast iron. It seems that certain constituents of the metal are dissolved away, leaving the less readily corrodable substances in a more or less weak state.

Sea water and water containing certain acids are known to cause this attack; the rapidity of the attack increases with the temperature and, as the water temperature in the economizer may be fairly high, the rate of wasting is liable to be rapid. Water containing an excess of magnesium sulphate together with sodium chloride will cause this attack. Water containing other magnesium salts is also harmful and such waters should be avoided. The water fed to the economizers should have been softened but the reactions should be complete before it reaches the economizer and the water should be free from a high acidity or alkalinity which softened water has been known to possess.

To some extent the boiler itself is protected from the effect of bad water by an economizer, as the water reaches the economizer first and the worst of the action will take place there, the water reaching the boiler in a purer state. This protects the boiler at the expense of the economizer.

In one instance, corrosion in an economizer and feed system was found to be taking place and on analyzing the water, it was found to contain a trace of sulphuric acid. This seemed to have caused the corrosion but its presence could not be accounted for. However, there was an acid pickling tank containing sulphuric acid in a building adjacent to the water storage, which was found to leak and it was evident that some of the acid had found it way into the water storage tank, for after the pickling tank had been repaired, all traces of acid in the feed water disappeared.

Brentford, England. W. E. WARNER.

TOTAL PRODUCTION of soft coal during the week of February 2, including lignite and coal coked at the mines, is estimated at 11,675,000 net tons. Compared with the revised estimate for the preceding week, this shows a decrease of 96,000 t., or 0.8 per cent.

When the Boiler Gives Way

YOUR ANSWER TO THE following questions will be much appreciated:

1. When would you consider a fire crack dangerous enough to cause you to discontinue the boiler from service?

2. Should the safety valve on a superheater be set for a higher or lower pressure than that on the boiler? Why?

3. How would you repair a blistered boiler plate?

4. If a crack 12 in. long was found in the side of a tubular boiler, what should be done?

5. How should the safety valve be blocked or held closed when making a hydrostatic test on a boiler?

A. Fire cracking in the girth seam of a horizontal tubular boiler is sufficiently serious to necessitate taking the boiler out of service for repairs when the leakage from the crack is sufficient to interfere with the fire or to cause corrosion of the shell. The boiler should be taken out of service immediately if the crack is found to extend through a rivet hole and into the plate in a direction opposite from the caulking edge.

2. Safety valves on a superheater are set to blow at a lower pressure than the setting of boiler safety valves so that in case the flow of steam through the steam pipe ceases and the fire is not checked, the safety valve on the superheater will blow and set up a circulation to prevent overheating of the superheater. Where the boiler with a superheater has several safety valves, it is customary to set one of the boiler safety valves to blow just in advance of the superheater safety valve, so with the boiler under normal operating condition and delivering steam into the header, the boiler safety valve will blow and give warning to check the draft to prevent the superheater safety valve from blowing and possibly drawing sediment into the header.

3. Blistered boiler plate is ordinarily found in the fire sheet of a horizontal tubular boiler. The outer skin of a blister may be chipped away and if of no greater thickness than 6 per cent of the plate thickness for quadruple riveted butt joint and no greater than 14 per cent of the plate thickness for triple riveted butt joint, no further attention should be necessary unless the blistering continues. If the lamination which caused the blister, travels at an angle through the sheet, as can be determined by the variation in the wall of the blister, patching may become necessary.

4. If it is positively known that the crack in the side of a tubular boiler is of no greater length than 12 in., the defective section may be removed and a circular patch put on, however, it is more than likely that the crack, if clearly evident for 12 in., is developing beyond that length. This can be determined by drilling a hole in the direction the crack is running. Evidences of the crack will be visible in the wall of the hole, if it has extended that far.

5. When making a hydrostatic test of a boiler, the safety valve is held closed by means of a gag. This gag is a yoke which clamps to the body of the valve and which carries a set screw so adjusted that the spindle of the valve is prevented from rising.

Use of Soda Ash for Washing Flue Gas

SODA ASH IS BEING used to wash flue gas of about the following composition: CO_2 7.5 per cent, O_2 7.5 per cent, CO-OO, N_2 15 per cent. The flue gases are produced by burning natural gas under boilers and are being blended with the vapors from a gasoline plant to make a gas of about 900 B.t.u. The purpose of the washing is to remove objectionable sulphur and nitrogen compounds; particularly the latter.

1. Now since sodium carbonate absorbs CO_2, the question has arisen, will the soda ash soon cease to be alkaline from absorbing CO_2 or is there enough air in the flue gases to "reclaim" the soda ash?

2. Will the soda ash itself under the conditions form a corrosive acid.

I might add that these flue gases are compressed to above 200 lb. and cooled by water jacketing before being washed with the soda ash solution.

3. Will not this moist gas with oxygen present be corrosive to ordinary steel or iron line pipe? H. C.

A. Absorption of CO_2 by sodium carbonate solutions will not proceed beyond conversion of the carbonate to an equivalent amount of bicarbonate. Sodium bicarbonate is alkaline and is capable of neutralizing the acids in the flue gases. Hence the fact that the flue gas contains CO_2 has no effect upon the efficiency of the solution in removing these acids.

2. Absorption of nitric, sulphuric and sulphurous acids by the soda ash solution will proceed until the sodium carbonate or bicarbonate are all converted to sodium nitrate, sulphate and sulphite. If the passage of flue gas through the solution is continued after neutralization of the soda ash is complete, the solution will become acid. Such a solution would be corrosive but its corrosiveness is due, not to the soda ash but to the presence of acid in the solution.

3. This question may refer to the flue gas either before or after scrubbing. The flue gas prior to washing will be corrosive to iron and steel pipe due to the presence of nitric and sulphuric acids and to a less extent because of the presence of oxygen and CO_2 along with moisture. After scrubbing, the amount of corrosion should be materially less. We would, however, expect the washed flue gas to be somewhat corrosive, due to the fact that the moist gas will contain oxygen and carbon dioxide.

Editorial Comment

High Pressure or High Temperature

Heat economy pushes designers forward to the use of high heat head. As a barrier stands the behavior of materials; creep under high temperatures and pressures, embrittlement under continued high temperature and stress, uncertainty as to the effect of continued high temperature on elastic limit and ultimate strength.

So far, American engineers have halted at 750 deg. F. and general practice pauses at 600 lb. pressure, although 1200 lb. is in successful use in a few plants. Even in those, the temperature at the turbine is held at around 750 deg.

In Europe, there appears a tendency to push the temperature limit higher. Rather accidentally, 842 deg. was used on one occasion with no discernible injury to the turbine. Now the Metropolitan-Vickers Co. is tendering on a 650-lb. plant to use 850 deg. and H. L. Guy in a recent paper suggests that 900 deg. at 400 lb. pressure is as safe as 700 deg. at 800 lb.

It would seem that special alloy steels, which are claimed to be free from creep at high temperatures may be found essential and the problem then becomes one of more expensive turbines and lower pressure boilers vs. the usual turbine and more costly high-pressure boilers. There is involved, too, the question of cost and upkeep on piping and auxiliaries for high pressure as against high temperature.

Data investigation and experience are needed to reach a logical conclusion, but the developments will be interesting to follow and worthy of careful study.

Guide Posts for Operators

Certain conditions in every power plant are beyond the control of the engineer in charge and each change requires a distinct "set up" in controllable conditions if highest efficiency is to be maintained. It is not sufficient that, with an increase in demand for steam, more fuel be fed to the furnace. Drafts must be adjusted, the rate of feedwater flow changed, the amount of superheat may change, furnace temperature is likely to vary, also the temperature and chemical constituency of the stack gases.

Wide variation in load calls for a different line-up of available units in operation. Temperature and barometric pressure of the atmosphere as well as the direction and velocity of the wind have characteristically distinct effects on the operation of a furnace. A recitation of these uncontrollable conditions, to which many more could be added, is only by way of emphasizing the need of investigation by the engineer to determine what controllable conditions should be maintained with each change in outside conditions.

At an industrial plant recently visited, the engineer pointed with just pride to the remarkably uniform consumption of fuel per pound of steam generated from day to day. Over the period of time represented by the records examined, the conditions of load and atmosphere varied widely but the economy of fuel consumption remained practically constant.

To obtain these results, the engineer had observed the effects of various changes and determined counter changes to meet each condition and each man in charge of equipment was given a table designating the conditions he is to maintain with each load condition. Recording instruments were available to show how closely the instructions were carried out and the whole system worked out beautifully with resultant economy in operation. The definite instructions to the operators take away all guesswork and the results of each individual's efforts are definitely recorded by the instruments.

Carefully established standards, faithfully executed, are sure to bring rewards of economy.

Men or Machines

Is there anybody who does not marvel at the wonders that are being performed by machinery? Control systems which have been developed seem almost human in their ability to maintain desired conditions and so confidently have men come to depend upon them that certain types of power generating plants are operated without attendants. This fact has led some plant owners to place duties upon their engineers which call them away from the power plant for an hour or two at a time.

Plants that are intended to run without attendants must be designed throughout with this thought in mind. Because an overhead coal bunker is installed to feed directly into the hopper of an automatic stoker, thus relieving the fireman of the arduous task of shoveling coal, does not justify the assumption that the boiler room equipment will operate without constant attention, even though automatic feedwater regulators, combustion control equipment, safety valves and other devices have been installed to save labor and supplement human skill in making adjustments to meet operating conditions.

Without doubt, every one of these automatic devices is a paying investment, even if it fails to reduce the operating force by a single man. Such devices act instantaneously to correct conditions for minute variations, whereas an attendant must take time and, with the most vigilant attention, a man cannot maintain theoretically correct conditions more than a small percentage of the time. Nevertheless machinery of whatever nature cannot take the place of the brains that control its operation. In every emergency, quick thinking and prompt action are required and no machine has yet been devised which can perform anything but routine work.

Machinery has reduced the work required of men in the power plant but with that reduction has come the necessity for more highly skilled technicians familiar with the construction and principles of operation of

every device under their care. The attendant's place during the operation of the plant is close by his machinery where he can observe any irregularities that may occur in operation.

Off Duty

This past winter, judging from reports from various parts of the north temperate zone, has been a hard one. Extreme cold, snow and ice in abundance, seem to have been the program generally and upon those regions ill-prepared for such conditions they imposed considerable hardship. In Europe, along the Riviera, where snow and ice prevailed for the first time in years, all the bearings on the Roulette wheels froze solid and betting was at a standstill for days at a time. So it was a hard winter. No group, however, suffered more from its effects than the "old timers," who have been telling the younger generation for years, how cold the winters used to be, for it shattered their most cherished theories.

For years, whenever opportunity permitted, they have been telling the youth of this land that the winters were growing milder—that it didn't snow now as it used to, that it didn't get as cold today as it used to, that cold waves aren't as frequent, in short, the winters of today couldn't hold a candle to the good old winters of their youth.

"Yaas," some old boy would drawl, "taint as cold these days as it used to be. Now, I kin remember back in '83 when the snow wuz so deep it tied up the railroad through Pumpkinsville for four days."

Of course, it probably never occurred to him that the iron steeds of the 80's were of smaller caliber than the big moguls of these days and that the inch or two of snow that tied up rail facilities through Pumpkinsville would have no effect on the score or more modern trains passing through the town today.

While the younger generation of today have minds of their own and accept such chatter for what they think it is worth, yet in just this way do false ideas gain strength. In time, if they hear these legends repeated often enough, they unconsciously accept them. This is true not only of ideas regarding weather and climate but all other things as well.

Most of our notions regarding the world in general are based upon what others have told us. Consider, for example, the general conception of equatorial Africa.

The popular impression is that central Africa is a steaming jungle, infested with ferocious animals and enormous venemous snakes—a country of oppressive heat and humidity—one vast impenetrable forest of tropical vegetation. This idea of Africa is not due to direct observation but has grown in the fashion of a legend, upon certain meager facts and unfounded assumptions.

That this idea of Africa is at variance with the real Africa is clearly brought out in the accounts and photographs of Carveth Wells, who conducted the recent Massee expedition to the Mountains of the Moon. That a great range of snow-capped mountains exists in the heart of Africa, directly on the equator is a fact, in itself, not generally known. Yet there it is, and not until 1906, when the Duke of Abruzzi climbed and mapped them no one, not even Stanley, had ever seen them. Absolutely uninhabited, shrouded in perpetual mist and clouds, from which dart great flashes of lightning almost every day in the year, these mountains stand in dreadful isolation.

In view of the location of these mysterious mountains, Mr. Wells' trip to them from Mombasa on the East Coast is interesting. His motion pictures are the only ones ever secured in this part of the world where blizzards are common. Instead of impenetrable jungle, his entire 1000-mile trip to the mountains was made by automobile over good roads through open country not unlike that of our own New England States. The climate likewise was like that of New England and from the day they arrived at Mombasa, overcoats were in order. Whenever a fire was lighted, explorers and natives huddled around it for warmth.

Wild animals? Yes, plenty of them but they weren't wild. Lions by the score gamboled along the road over which the automobiles passed but scarcely noticed the explorers. They were decidedly nonchalant. In one case, a shepard was found tending his flock in one corner of a field while a dozen or more lions disported themselves a few hundred yards away. Wild animals indeed, but harmless!

Snakes! Mr. Wells didn't see any. And yet this is equatorial Africa. True, in certain parts of Africa along the West Coast there are patches of jungle but so are there in Florida. A few explorers touching these parts came back with perfectly honest intentions, no doubt, but evidently did not indicate the limits of their travels, for today many believe that most of Africa outside of the Sahara is a steaming jungle.

Similarly our notion of the Arctic is based mostly upon our imagination coupled with a scant knowledge of geography. When we think of the Arctic, we visualize unending snow and ice fields. Yet Steffanson, the explorer, has written a book called "The Friendly Arctic" in which he describes a beautiful country with marvelous flowers and a delightful summer climate.

Thus, most of our notions of things we are not directly concerned with are composed of, say, 10 per cent fact and 90 per cent imagination. This being so, it would seem that the 10 per cent fact should be reasonably pure, not only as regards Africa and the Arctic but also as regards the character of the winters now and in the good old days. One weather bureau record is worth ten years of some old timer's picturesque reminiscences.

IT IS SELDOM practical to build electric generating plants at coal mines, as there is rarely sufficient water for efficient condenser operation. The efficient operation of steam turbines requires from 500 to 900 t. of condensing water for every ton of coal burned and in many large cities, the electric generating stations pump more water for condensing purposes than is required by the entire city for other usages.

THERMAL EFFICIENCY of power plants has been steadily increasing as equipment is improved. An ordinary steam plant with noncondensing reciprocating engines will have an efficiency of about 10 to 12 per cent. By using high-pressure multi-expansion condensing engines, this can be increased to about 20 per cent. The most modern steam turbine plants using the reheat cycle may get as high as 30 per cent, while a good Diesel engine will have an efficiency of from 30 to 34 per cent. The ordinary locomotive has an efficiency of about 8 per cent, due largely to the high draft and high rates of combustion.

Fourth Chicago Show Mecca for Mechanical Engineers

HERALDED by the congratulations and felicitations of Thomas A. Edison, the Fourth Midwestern Engineering and Power Exposition opened in the Chicago Coliseum at noon, February 12 amid a blaze of glory. The attendance at this show, although apparently below that of last year, was of a quality which pleased the majority of exhibitors.

Getting away to a slow start, the show was in full swing by the middle of the week, the crowd thinning out early on the last day of the show Saturday, February 16.

As a whole, the show was attractive and well arranged. A number of sales organizations representing manufacturers in the Chicago district were active and had their exhibitions grouped together in single displays.

Chicago Sales Representatives

In a large and attractive booth, D. H. Skeen & Co. displayed a varied and comprehensive exhibit of the products of the various companies that it represents.

Tri-Lock grating made by Tri-Lock Co. was shown here. This has been designed to include diagonal members between the parallel bars in order to obtain better visibility and to obtain a more irregular design, with facing through which tools or other objects can not be dropped.

Sections of a forged and hammer welded boiler drum, designed for 450 lb. pressure, 750 deg. total temperature, was displayed as one of the products of M. W. Kellogg Co. Another product of this company on display was the Kell-Raph plated steel gasket for pipe lines.

On the Mercon Regulator made by the Mercon Regulator Co., attention was called to a 6-in. regulator designed for 650 lb. pressure, with internal bypass construction, this unit being made for installation on unit No. 2 at Powerton station for excess pressure control.

Improvements on the Henszey De Concentrator made by Henszey De Concentrator Co. were also pointed out. A new paddle wheel water meter has been provided on this device, together with a differential thermostat, to keep a constant temperature difference between the blowdown and the makeup.

A flat type gage glass made by the Stets Co. for pressures of 900 lb. was shown equipped with an illuminator made by National Co. which projects light through a hood from behind the gage glass, so that the light is reflected from the meniscus of the water level, thus indicating its position.

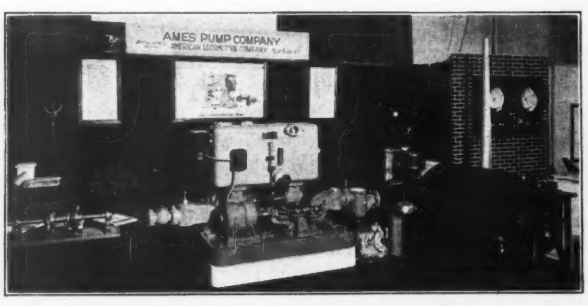
One of the features of the Skeen exhibit was the full size model of the new type Air Preheater Corp. Ljungstrom air preheater described in detail on page 273 of the February 15 issue. This model was designed for a 750-hp. boiler for use with separate fans.

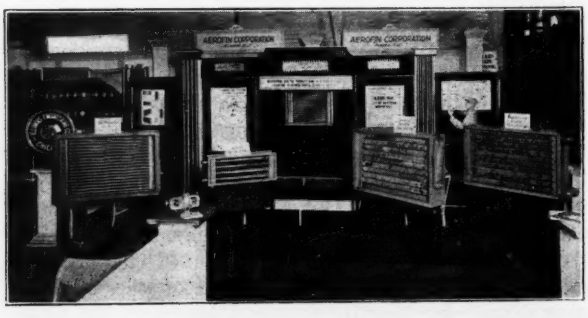
Allen-Sherman-Hoff Co. showed many drawings demonstrating interesting applications of its hydrojet system for sluicing ash. The hydrojet for roundhouses or ash dumps for locomotives was pointed out as a new field for this equipment. Another interesting application stated to be on two ships now building equipped with chain grate stokers, a screw conveyor taking the ash from under the stokers to a sump from which it is pumped overboard.

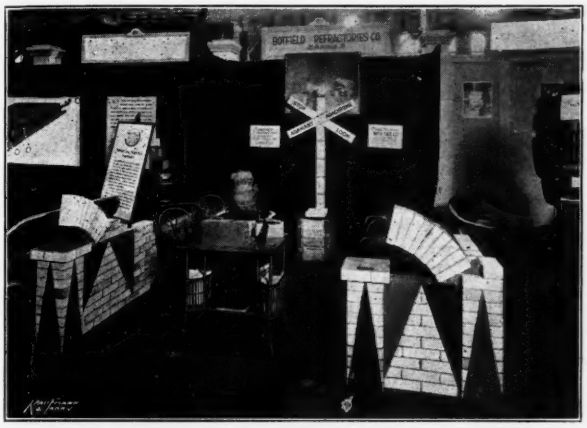
Among the dozen or so manufacturers represented in Chicago by Ernest E. Lee Co. and grouped together in the northeast corner of the hall, were a number of new developments which attracted attention.

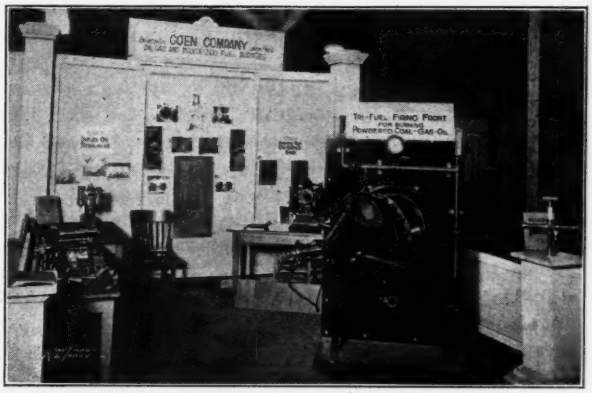
The American Pulverizer Co. had on display one of the American ring crushers, equipped with Timken roller bearings which has been incorporated in the S type of crusher and can be furnished with any of their other types if desired.

Atwood & Morrill Co. showed a new adjustable









damper regulator. This regulator is actuated by the steam pressure admitted to the diaphragm, which in turn controls the hydraulic cylinder, the piston of which is connected by a system of levers to a chain working with its boiler dampers. By a clever arrangement of levers, movement of the damper can be varied over the entire range, while the piston travels a constant distance of 15 in.

Blaw-Knox Co., in the display of the Andrews-Bradshaw Div., featured the new drum-type Tracyfier, designed for installation above the steam drum or elsewhere in the steam line as conditions may demand and is described in more detail on page 123 of our January 15, 1929 issue.

Thermo-Fit, a new Drake Non-Clinkering Furnace Block Co. water wall, was the center of attraction at the booth of this company. This wall consists of a face block of solid metal or refractory, which is clamped to the tube and positive metal to metal contact made between the tubes and blocks by a soft alloy gasket.

Stokers were an important feature of the show and one of the most interesting exhibitions was at the booth of the Illinois Stoker Co., where they showed the new stoker drive, take-up indicator and damper regulator, as described in detail on page 111 of our January 15, 1929 issue.

Dexter tank car outlet valve reseating machines, were the principal exhibit of the Leavitt Machine Co. This machine is used for reseating tank car outlet valves without removing them from the tanks. The work is done by a workman from the inside of the tank.

Boiler feedwater regulation equipment for all services was exhibited by the Northern Equipment Co. The type SS differential water-pressure regulating valve, described in detail on page 118 of the January 15, 1929 issue, and the new Copes type DS pump governor described in detail on page 329 of the March 1 issue were two new products exhibited.

Himelblau, Agazim & Co. displayed products of the various companies which it represents in the Chicago territory. Among these, the following featured new developments.

Simplex top hung adjustable radiator brackets were demonstrated by the Clip-Bar Manufacturing Co. These hangers are designed for carrying and supporting tube or wall radiator from a simple wall support, eliminating the necessity of using a great variety of supporting hooks for shoes, several lengths of wall plates and a number of sizes of tie rods. Brackets are adjustable both vertically and horizontally and radiators can be adjusted after placing on a hanger.

Therminsul, a product of the Minwool Insulating Co. a new account of the Himelblau, Agazim & Co., demonstrated the properties of its insulation by a number of tests.

A new departure in the line of turbine-condenser expansion joints were featured by the Dennis Engineering Co. The Dennis expansion joint may be installed horizontal or vertical, to permit proper expansion in any direction without straining the expansion joint. A copper shield is expanded into place by inserting split steel rings upon which the flat steel springs exert sufficient pressure to seal the joint properly with the flanged surfaces of turbine and condenser.

The Ediplate Corp. featured a new Ediplate float made in copper or nickel. It is made from a single sheet of electroplated material, a fact said to eliminate the possibility of electrolysis through contact of two dissimilar metals.

The O. E. F. No. 2 oil cooler, the latest development of the O. E. Frank Heater & Engineering Co., was exhibited in the booth of this company. The shell, chamber or channel box and all openings are cast integral. The lines leading to or from this unit need never be broken, or in any way disturbed to allow removal of the nest of tubes. The shell and chamber are made of cast iron or steel, of ⅝-in. OD Admiralty Metal or Steel, with baffles and tube sheets of bronze or steel.

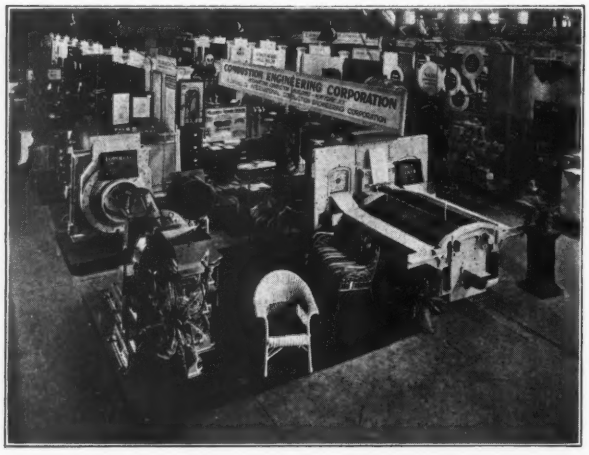
Centrifix Deconcentrators, the latest product of the Centrifix Corp., was featured by Burnham & Lindsey, Inc., who represent the Centrifix Corp. and the Vulcan-Soot Cleaner Co., Chicago district. The Centrifix Deconcentrator consists of a turbo concentrator installed in the top drum of the boiler and circulating pipe which connects the concentrator with the lower drum or header, depending upon the type of boiler. Precipitates separate into a relatively small eject stream which lends itself to continuous blow-down, the blow-down being regulated by the Micro-Blow-Off valve. Two self-contained, monel metal trimmed Vulcan operating heads were featured by the Vulcan Soot Cleaner Co., which demonstrated a new design with totally enclosed gear, flange for dismantling and removing elements without disturbing the adjustment of the head. Detail parts of the blower and Crodon corrosion-resisting elements were also exhibited.

In display, grouped around the booth of the Barrett-Christie Co., manufacturers which they represented in

the Chicago District exhibit their products. One of the principal pieces of new equipment was the forged steel trap of the Armstrong Machine Works. This is built in all sizes for pressures up to 900 lb. and can be supplied extra-heavy for pressures up to 1450 lb. The operation and design of the trap itself is the same as the standard Armstrong trap, the operation of which was demonstrated by a glass model.

Another new product presented was a low-pressure return trap and air eliminator for vapor systems displayed by Kieley and Mueller, Inc. This consists of a seamless copper float on a lever which operates the double ported valve when condensate collects. A special arrangement passes the air out of the vent before opening the steam valve to return the condensate to the boiler by gravity.

Two new Strong, Carlisle and Hammond Co. traps were shown in the booth of Meyer Ekstrom Co., sales representatives of the company. These traps, both



made of Anum-Metl, are recent developments. The Anum-Metl, 40 series, is a bucket trap, which, filling with condensate, opens the valve to permit discharge. The other, the 20 series, is an inverted bucket trap, condensate entering in the bottom raises the trap and opens the discharge valve in the top.

At the booth of the J. W. Murphy Co. were shown the products of the various organizations for which it is sales agent.

The Hays Corporation, one of these companies, had on display a draft gage element for use on its draft recorder and indicator. This employs a diaphragm of animal membrane, the pressure on this actuates a spring, driving a pointer over the scale. The new Hays CO_2 recorder of the same company was described in detail on page 108 of our January 15 issue.

Stokers

The Brownell A-1 automatic underfeed stoker was featured in the booth of the Brownell Co. This is a duel control unit with a motor drive and blower built integral; the same mechanism that changes the rate of coal feed also adjusts the air supply damper, automatically maintaining the fuel and air supply in proper relation. Either fuel or air may be independently adjusted by hand if desired. This company also exhibited a full size model of the Brownell Master welded boiler and the single retort side dump type stoker.

Combustioneer, Inc., exhibited among other models, its new stoker for home use. This stoker was described in detail on page 749 of our July 1, 1928 issue.

A new feature of the Forced Underfiring Corp. was the new De Luxe Iron Fireman, a small household stoker, smaller than the Iron Fireman, Jr., designed for home or apartment house buildings.

Among the many exhibits of the Combustion Engineering Corp. was a full-size type E stoker in operation. This stoker which had the new type E electric drive was built for the U. S. Gypsum Co. and will soon be installed in one of their plants. They also called attention to the changes in their Type C combination pulverized coal burner.

Johnson & Jennings Co. exhibited the Stowe forced chain grate draft stoker, the manufacture of which they recently took over. Construction and operation of this stoker was demonstrated by means of a full-sized but shortened model set up to show the many features of design.

Riley Stoker Corp. exhibited a full-size operating unit of a Jones stoker to demonstrate the new Riflex mechanical drive, described on page 327 of the March 1 issue. They also exhibited sections of the La Montube screen, consisting of small diameter, water-cooled tubes, designed primarily for use in h.r.t. boilers. Attention was also called to important changes in the Atrita pulverizer, which is now being built with new casing, newly designed liner construction and other changes tending to give greater capacity and lower power consumption.

A full-size sectional model of the Westinghouse underfeed stoker, set up with a forced fan under control of a grid glow tube, was featured by the Westinghouse Electric & Manufacturing Co. By means of an operating model they also demonstrated the new Undulating grate, used for Westinghouse multiple-retort stokers in large boiler units. This type stoker was recently installed in the new section of the Hudson Ave. station.

King Coal Model B stoker, as described in detail on page 111 of our January 15, 1929 issue, was the principal exhibit in the Harrington Stoker Division of the Whiting Corp. booth.

Pulverized Coal and Fuel Oil Equipment

The booth of the Coen Co., Inc., was devoted to oil burning equipment, the main feature being the new Tri-Fuel front designed for fuels of gas, fuel oil or powdered coal without burner changes. It was equipped with a mechanical Type A burner, socket, flexible hose, thermometers and gages as in actual service.

Operation of an air-swept tube mill applied to pulverized coal-fired boiler installation was shown by a scene-in-action at the booth of the Kennedy-Van-Saun Mfg. & Eng. Corp. The installation shown was a recent design ball mill, with worm drive, the installation itself being designed for anthracite coal. A working model of the Unipulvo underfeed unit pulverizer was the principal feature of the Strong-Scott Mfg. Co. exhibit. This unit was described in detail on page 219 of the February 1, 1929 issue.

Pulverized Fuel Equipment Co. called attention to improvements in some of the details of its unit pulverizer such as the use of alemite lubrication on slow speed bearings and Lewellen variable speed drive on the feeder.

Dust Collectors and Breechings

Sections of forced draft ducts, indicating the use of blades or vanes, designed as indicated by the research work of the General Electric Co. was a feature of the exhibit of Connery & Co. booth. This is a new development intended primarily to reduce the pressure losses in turns and elbows of forced draft ducts.

For eliminating dust from flue gas of pulverized coal-fired boilers, a new development known as the Dustrap was shown by the Green Fuel Economizer Co. This device is installed in the duct carrying the gas and consists of a series of deeply corrugated barbed plates, suspended in a case to form alternate vertical nozzles and expansion chambers. A rapping device is provided to shake the dust into the hopper from which it is taken by a screw conveyor.

Known as Type 4, a new Thermix stack for the production of mechanical draft and the removal of cinders, dust and fly ash from gas in stoker or pulverized coal-fired furnaces, was exhibited by the Prat-Daniel Corp. In this unit, a Thermix stack is combined with Type 4 fan, the scroll of which is about twice the normal length. Dust is concentrated near the outside periphery of the fan and by means of an opening along the outside periphery a portion of the gas is continuously withdrawn into the cyclone collector, carrying the dust which is deposited in the cyclone, the clean gas passes back to the suction side of the fan.

Bethlehem Steel Co. demonstrated a new model oil burner installation in actual operation by use of a spray of colored liquid, the demonstration installation being so arranged that the effect of changes in draft upon the flame travel and distribution could be studied.

Furnace Walls and Refractory

Sections of Carbofrax walls, which recently created a sensation in an industrial installation under unusually high rating, were featured by the Carborundum Co. This is a water-cooled wall of Carbofrax brick of a special shape, made to be used without cement or without being bonded or fused to the tube.

Plastic furnace linings and 4 new high temperature cements were featured in the exhibit of the John L. Cummings Co., recently organized by a man with wide experience in this field and represented in Chicago by Bell & Gossett.

Section of a new wall of the type which will be installed at Deepwater was shown by the M. H. Detrick Co., in an extensive exhibit, including the sectional supported wall with natural air ventilation and cooling.

Economy air-cooled walls were the principal items of interest at the exhibit of the Furnace Economy Co. These walls are suited to all sizes and types of boilers, adaptable to either forced or induced air flow, for pulverized coal, stoker, oil or gas firing. They can be built inside existing furnace chambers.

Small, compact, water-proof, burlap, packages of Ramtite plastic furnace lining, put up in 100-lb. lots, is the latest development of the S. Obermayer Co. A number of these packages were on exhibition at its booth.

Construction of water walls of plastic cement was featured by the Plibrico Jointless Firebrick Co. This application is described on page 105 of our January 15 issue.

Boilers, Turbines, Piping and Accessories

Soot blowers for radiant superheaters, known as the Diamond Model I Blower, was a special feature of the Diamond Power Specialty Corp. exhibit. This new model, designed with a rack and pinion so that the element can be withdrawn from the furnace after blowing the tube, is made especially for radiant superheaters and water walls.

Type EF, a new Murray Standard turbine, especially designed for driving small generators or auxiliaries, attracted much attention in the booth of the Murray Iron Works Co. This new series which is built 20 to 40 hp. in pressures up to 250 lb. and temperatures up to 525 deg. F., at speeds from 1800 to 3600 r.p.m., is the latest development of this company.

Sections of headers which will be installed in the new high-pressure plant of the Adolphus-Busch Co. of St. Louis, were featured by the Springfield Boiler Co.

This is a new steel header for pressure up to 900 lb. per sq. in., cast from a special mixture of electric steel.

A novel feature of the display of the Stockham Pipe & Fittings Co. was a special fitting made for the Gorgas Plant of the Alabama Power Co. It is a 12 by 14-in. cast steel tee with a side outlet for 600 lb. working pressure and has a total weight of about 1600 lb.

Yarnall-Waring Co. featured its new Yarway steel floatless Hi-Lo alarm water column and Yarway-Sesure inclined water gage, in which a flange valve is used to facilitate the removal of the valve without disturbing the piping of the gage.

Motors and Electrical Equipment

A complete line of small motors ranging from 1/80 to 1/10 hp., built with reduction gears to reduce the speed of the motor from 4000 by ratios of 8½ to 1 to 1100 to 1, were shown by Bodine Electric Co. Here also was found a small reversible alternating current motor designed especially for boiler room control.

The new size AO valve control for valves 1½ to 3 in. in size was displayed by Cutler-Hammer, Inc. The new Dur-ristor, grid resistor designed originally for steel mill duty was also displayed. This is intended for heavy duty service to withstand vibration and is made of unbreakable continuous strips with steel supporting frame and adjustable connectors. Also exhibited were a new water-level alarm system to give automatic visual and audible indication of water level; a manually oper-

ated alternating current controller for slip ring motors and a direct-current manual motor starter, consisting of motor starter and U-Re-Lite in one case.

I-T-E Circuit Breaker Co. showed its new full automatic double throw 1000-amp. transfer switch designed especially for such installations as hospitals and theatres, the all steel U-Re-Lite panel, with alternating or direct-current remote controlled. The type W units of this line can be supplied for from 5 to 400 amp. with a rupturing capacity of 30,000 amp. at 480 v., 3-phase, 60-cycle. The type LX circuit breaker for general use was also shown at this booth. This is made in capacities up to 1250 amp. at 550 v. and in both open type and U-Re-Lite type.

A new battery using the Plante A plate in glass jars was exhibited as the latest product of the Wubco Battery Corp. This battery is designed for long life, well maintained voltage under high load rate and is designed primarily for station battery service.

Lubrication and Oil Filters

DeLaval Separator Co. presented new insulating oil maintenance outfit combining in a compact, all-steel,

portable unit a centrifugal oil purifier, direct-connected blotter press for use in connection with the centrifugal for purifying carbonized circuit breaker oil; self-starting purifier with push-button control; push-button controlled rotary pumps capable of operating against 100 lb. pressure; a three-unit electric heater equipped with thermostatic cut-out and four roller-bearing wheels with wide tires, as the principal features of design.

Illustrating the different viscosities of oil, the Texas Co. made a display of four parallel glass tubes filled with oil of different viscosities, through which steel balls rolled. The entire arrangement was tipped automatically, the difference in the speed of the balls being the measure of the viscosity of the oil.

Well-arranged model power plants illustrating good Diesel engine, steam turbine and steam engine practice, was shown in the booth of the Standard Oil Co. and was used to demonstrate the advantage and economy of carefully designed lubricating systems and good oil.

A new filter for oil and pressure lubricating systems was shown by the Wm. W. Nugent & Co., Inc. This filter is installed between the oil circulating pump in the lubricating machine and was described in detail on page 1063 of the Oct. 1, 1928 issue.

Duplex vacuum heating pumps and receivers combining hurling water and boiler feed pump impellers on the same shaft was the principal item of interest in the booth of the Ames Pump Co., Inc. Two pump units are provided with the motors controlled automatically by means of the vacuum regulator and float switch, either of which will start or stop the unit.

In addition to changes in the Condo-vac, the Chicago Pump Co. demonstrated the Little Giant electric cellar drainer, a small, vertical, float operated centrifugal pump, driven by a ¼-hp. motor.

Changes and new designs in the non-clog sewage ejector were featured by the Economy Pumping Machinery Co. Announcement was also made that the Economy condensation and vacuum pumps will be marketed under the name "Hoffman-Economy" by the Hoffman Specialty Co. of Chicago. One of these units was on exhibition at the booth of the latter company.

Hoffman Specialty Co. also featured a new Hoffman differential loop, a simple device which prevents water from backing up in the return main and at the same time maintains a constant differential pressure between steam and return mains.

Of special interest in the exhibit of the Nash Engineering Co. was the new suction sump pump, an open impeller centrifugal pump for sump service. In this pump, an open impeller combined with a vacuum priming pump in the same casing, so that the pump and priming motor are of the horizontal type and are mounted above the sump, only the suction pipe being submerged. The priming pump exhausts the air from the casing and when it reaches the impeller it operates as a simple centrifugal pump. The capacity ranges from 30 to 250 g.p.m.

Sanitary pumps made of German silver, nickel-plated, designed primarily for handling milk and cream, were featured by the Westco-Chippewa Pump Co., Inc. This is a new line recently completed, with a range of capacities of from 5 to 200 gal.

The Type E.M., a new line of centrifugal pumps developed by the Weil Pump Co., was the principal item of interest in its exhibit. This is a new line of 4-stage centrifugal pump built from 2 to 4 in. with ball-bearing construction, designed for direct connection to motor.

Arranged to give the lowest possible water line in the system, the new condensation pump and receiver unit of the Skidmore Corp. is built to handle 2000 to 40,000 sq. ft. capacity of radiation. It is of compact design, with interchangeable pump features and it is not necessary to disturb the piping when changing the pump propeller or motor. It is designed so that if conditions change, a new pump and motor can be installed in the same volute to meet the new condition.

Condensation pumps for the return of condensate to the boiler for heating and process work and a new unit heater were exhibited by The Trane Co. The condensation unit consisted of a compactly arranged pump, motor, motor protective equipment, float switch control, receiving tank, piping between pump and tank and companion flanges for suction and discharge of pump. The units are furnished completely hooked up for installation.

Heating, Ventilating and Air Conditioning Equipment

New Booster heating coils built two rows deep and designed to heat air from 70 to 130 deg. F., were exhibited as the newest products of the Aerofin Corp. These booster coils, which are built two, four, six or

eight rows high, are designed for installation under windows to counteract window losses.

Ventilating and humidifying equipment for dwellings were exhibited by the American Blower Co., which featured its improved wall type made with rubber gaskets on the doors and without louvers.

Chinookfin heaters, turbo air washer, complete with heater, fan and motor and Discfin unit heaters, were shown in the booth of the Bayley Blower Co. The Chinookfin is a new indirect heater, designed with one header, each type being an individual member with no return bends, nipples or elbows. Expansion and contraction strains are avoided in the construction and any tube may be removed and renewed without disturbing the others.

Introduced as an innovation in industrial unit heating, the Lowboy and Highboy heaters of the Buffalo Forge Co. were the principal item of interest in this exhibit. This unit is described in detail on page 33 of our March 1, 1929, issue.

Automatic thermostatically operated radiator valves, designed for 110 and 18v. were exhibited as the latest application of the Cook Electric Co. bellows. These valves are made to control the temperatures of one or more rooms and are built in sizes up to 1 in. Contact for the electric circuit is made and broken by the thermostat. A resistance unit above the valve heats and vaporizes the liquid in the bellows and closes the valve.

Domestic heaters, incorporating a small motor-driven blower in the base, were displayed by the Erie Heating Systems, Inc. These units are made with steam or electric heated elements so arranged that all the air passes over them and is heated uniformly.

In the same booth, the United States Ozone Co. exhibited and demonstrated its new device for ionizing air. This unit is designed to give air the same quality and property as the sun and thus make it easier for the blood cells to utilize the oxygen. This unit, which is put out in the form of an attractive wall cabinet, has a small blower in the base, the air being passed up and over a vacuum tube.

Combining the features of simplicity, accuracy and beauty, the DeLuxe Aqua-Therm of the E. Vernon Hill Co., has been designed to meet the demand for an accurate instrument for wet and dry bulb reading. This instrument has a wet and dry bulb scale and chart by which the relative humidity can be found directly without reference to other charts or tables.

Grinnell Co., Inc., displayed its new Duotherm control for regulating room temperature with unit heaters. Duothermostats in the system control high and low temperatures, the thermostats being located at suitable points in the rooms to be heated, and controlling the operation of the fans in the unit heaters. The I-beam clamp of the company, designed for supporting pipe in sizes up to 24 in. on I-beams, was also displayed. Three sizes of this clamp are made to care for all pipe sizes.

Remote control valves for zone control of heating systems were shown by the Illinois Engineering Co. These valves serve to vary the steam supplied to the zone system under the control of a thermostat in each zone. They are motor-operated with a special valve stem arrangement to prevent stalling. They can also be used in pressure reducing valves to keep the constant pressure in each zone, depending upon the conditions.

Vapor thermostats for industrial, process and heating processes were featured in an extensive exhibit by the Klipfel Manufacturing Co. This thermostat is a complete operating unit in itself, utilizes no compressed air, water, electrical or other operating power and operates the valve directly. It is made in both the lever and spring types.

For automatic control of mechanical refrigeration units, the Jas. P. Marsh & Co. developed the Marsh Merkustat, which was exhibited in its booth. This is a pressure actuated Bourdon tube, operating a mercoid switch. It is a simple, rugged, sensitive device utilizing a nonbreakable mercury-to-mercury tube with a double on and off indicator and is made of different metals, depending upon the refrigerant employed.

Unit heaters embodying a new brazed heating element were shown by the McQuay Radiator Corp. These units can be used for steam pressures up to 150 lb. per sq. in. without danger of melting the connections as is the case in ordinary soldered units. One of these new units, built for office use and measuring 14 by 10 by 8 in., was exhibited as the company's newest product.

Weighing only 300 lb. the new Model 1401 unit heater was shown by the Modine Mfg. Co. This unit, designed for a maximum of 125 lb. pressure and utilizing a ½-hp., 1150-r.p.m. motor, is equivalent to 1300 ft. of cast-iron radiation.

Steam for the above exhibit was furnished by one of the new Sterlco steel, sectional water tube, gas-fired boiler in the adjacent booth of the Sterling Engineering Co. The company also exhibited the Ketchum Compeller, a positive propeller type water circulator used to improve the circulation in piping systems.

Filters for building ventilation, compressors, central stations, Diesel engines and chemical processes were exhibited in the booth of the Midwest Air Filters, Inc. The new SH and SV sinuous filter was featured. This was described in detail on page 275 of our February 15, 1929 issue.

New lines of motor-operated valves were featured by the Minneapolis-Honeywell Regulator Co. Motor-operated valves are built in large, intermediate and small sizes, up to 3 in. and for pressures up to 150 lb. One of the newest additions in this line was the 25-w. motor-operated steam radiator valve, built in sizes up to 1½ in. and for pressures up to 10 lb.

Pocket type Airmat filters in commercial sizes were exhibited by the National Air Filter Co. The principle of this filter, which utilizes a fibrous material for air cleaning, was described on page 750 of our July 1, 1928 issue. The unit exhibited has vertical pockets which are easily replaceable, so constructed in sections that they fit together in any desired combination of shape or size.

Rotary ball-bearing roof ventilators and a new design of air intake box were exhibited by the Swartwout Co. These air intake boxes, made of 12-gage iron, are of sturdy uniform construction. The ventilators and intake boxes can be provided with vitreous enamel for use in locations and processes when corrosion gases are encountered. Application of the Swartwout desuperheater governor was also demonstrated. In this the generator to steam line controls the amount of water admitted to its desuperheater. The superheat may be removed entirely or reduced to any desired amount.

A continuous air filter was shown in operation at

the booth of the Reed Air Filter Co. This is a continuous filter with elements covered with Bakelite and wood flour and was described in detail on page 955 of our September 1 issue.

An entirely new development in steam heating was shown and demonstrated in the booth of Warren Webster & Co. This system, which is an innovation in steam heating practice, is described in detail on page 193 of our February 1, 1929, issue.

Model 712, a new unit heater, was shown in the booth of the Young Radiator Co. These units which occupy less than 3 cu. ft. and weigh only 125 lb., are designed for a maximum steam pressure of 125 lb. per

sq. in. and are equivalent to about 600 sq. ft. cast-iron radiation. The motor used on this unit is a 1/6-hp., 1150-r.p.m. unit.

Traps, Valves, Blowers and Regulators

The new portable blower known as the Tornado Hot and cold model 6, driven by 1/3-hp. ball-bearing motor, was a feature of the exhibit of the Breuer Elec. Mfg. Co. This is designed primarily for drying switch boards or electrical equipment. The unit can be used with or without electric heating device.

New applications of a portable blower were demonstrated by the Clements Mfg. Co. in connection with a portable gas-electric blow-torch for giving temperatures up to 2300 deg. F. The operation is simple; it is only necessary to turn on the gas and electricity and apply a match.

One of the many appliances exhibited by the Cochrane Corp., was the tandem blowoff valve with one-piece forged steel body, which was described in detail on page 1063 of our October 1, 1928 issue. Another product featured was the Cochrane discharger, a pilot operated trap designed to handle large quantities of water under the highest pressures, as from steam purifiers. The pilot valve is operated by solid displacement bodies, while the main valve is moved by steam pressure acting upon a piston.

Safety valves designed for 2000 lb. pressure and 1000 deg. F. for oil refinery service were featured by the Crosby Steam Gage & Valve Co. These are known as the model JJA603. It also exhibited its nozzle type HN safety valves for steam boilers. A cooling spool has been inserted between the valve and the spring so that when operating at extremely high temperature the spring is not affected by the steam temperature.

For close pressure regulation of any fluid, the Fisher Governor Co., Inc., developed its master reducing valve with auxiliary control. Although this regulator is applicable to any service where close regulation is required, it was designed primarily to work in conjunction with extraction turbine, controlling the high pressure steam line to make up requirements beyond that supplied by the turbine. The valve is made in all sizes between 1 and 18 in.

Air eliminating traps for steam heating systems consisting of cast-iron body, copper float, brass valve mechanism for eliminating air were shown by the Sarco Company, Inc. The Sarco combination float and thermostatic traps were also featured. This is designed for heavy-duty service trap which will not air bind. A thermostatic bypass is incorporated in the float trap body. Air is bypassed and discharged by the thermostatic trap at the top and condensate is discharged from the float-operated valve at the bottom of the trap. It is built for pressures up to 10 lb. per sq. in.

Gears, Belting and Speed Reducers

Powered by 60-hp. Fairbanks, Morse & Co. Diesel engine, a Whitcomb industrial locomotive, was one of the most impressive exhibits of the show. It also featured its Flex-Mor drive, a new belt-drive, designed for operation with grooved sheaves.

Two new models were exhibited by the Clipper Belt Lacer Co., one of these a 10-in. cutter operated by a hand lever, and the other a 6-in. speed lacer, in which a ¾ turn of the crank forces the lacing hook under the belt.

New speed reducers of the herringbone gear type were shown by the W. A. Jones Foundry & Machine Co. These had herringbone continuous speed gears, Timken roller bearings and unusually heavy housings,

well ribbed with heavy feet and foundation bolts. The gears run in a bath of oil.

The new full herringbone reduction gears were shown by Palmer-Bee Co. These are equipped with anti-friction bearings with a special sealing device designed to keep the oil in and the dirt out. They are supplied in capacities from 1 to 300 hp. and for speed ratios from 1 to 2, to 1 to 300.

Shepard Electric Crane & Hoist Co. had on display a one-ton and a two-ton hoist, showing the recent construction of radiating fins on gear housings, to dissipate any heat that may be generated.

Several sizes of the JFS variable speed tranmissions were shown by the Stephens-Adamson Mfg. Co. These speed changers are now made with ball bearings and can be furnished in six sizes ranging from ⅛ to 25 hp.

They are built in speed reductions of 8 to 5 and 40 to 1. Another feature of the exhibit was the new No. 455 belt conveyor carrier, double ball bearing a three-pulley carrier, designed with new style roller supports which afford protection for the bearing.

Electric automatic control for variable speed transmission was featured by the Reeves Pulley Co. Changes are made directly by means of a fractional horsepower reversible motor, mounted on a bracket above the shifting screws and connected to the latter by means of a single reduction of spur gears. The motor and magnetic switch are furnished to conform with current specifications.

Packing, Bearings and Special Metals

Application of the Cooke Seal Ring to a high vacuum pump designed for making radio tubes was featured by the Cooke Seal Ring Co. These pumps, which produce a vacuum of 0.001 mm. are used for making vacuum tubes.

Metallic packing of a new design, incorporating elastic core, to give resiliency, was featured in the exhibit of the Durametallic Corp. Packing of this kind can be furnished in any grade for any service.

A new line of bearings known as the Maximum Construction Type in both single and double row with large ball and deep groove was shown by The Fafnir Bearing Co.

Metal oil return packing for use on steam, oil, gas and Diesel engines, gas or air compressors or any type of machinery of enclosed crank case type, were exhibited by the Garlock Packing Co. This company also exhibited the new Chevron packing, especially designed for heavy service, consisting of duck and rubber rings, which expand under pressure or compression, to give close contact with the rod without excessive pressure.

In the booth of Johns-Manville, Inc., various equipment and processes of manufacture were illustrated. This company has recently taken over Red Jack packing which was featured in the exhibit. Banner Rock Products Co. and Celite Products Co., both of which were taken over by Johns-Manville, Inc., recently were also featured in an extensive exhibition.

In a clever exhibit designed to show the uniformity of its products, The New Departure Manufacturing Co. had an unusual exhibit. Ball bearings dropping by gravity on to a plate, bounced through a synchronized ring to another plate and then back to the container. It is said that the exhibit has worked as long as two weeks without a single ball missing.

Application of ball bearings to the new line of totally enclosed Allis-Chalmers motors were featured by the Norma-Hoffman Bearings Corp. Sectionalized motors were on display to show the application and construction.

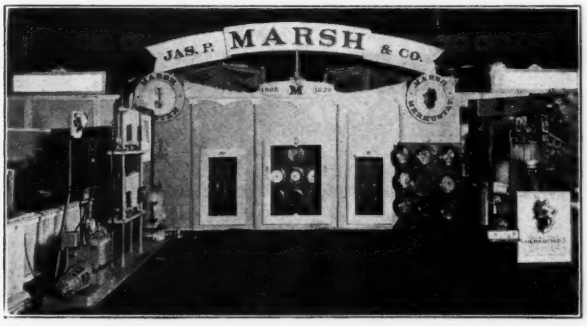
Finished cast bars were shown in the display of the Sumet Corp. This new bar was developed primarily for use by manufacturers turning out small parts of automatic machines.

Lavafelt quilt and pipe covering was featured by the Weber Insulations, Inc. This is a mineral insulation put up in sheets or quilts between wire netting and can be cut to any desired size.

Instruments

At the booth of the Bristol Co. was shown a new meter panel designed for the minimum of space and carrying 4 rectangular type meters each with 6-in. charts. Another interesting meter was a 3-in-1 type, in which three units with 6-in. charts were arranged in line on a 16½-in. panel in one case by scattering the charts one over the other; a new form of draft controller described in detail on page 107 of our January 15 issue. There was also a diaphragm type controller actuated by the steam pressure in the main header which regulates the speed of the fans supplying air to the furnace.

Copper tube couplings, bending and fabricating equipment, were demonstrated by The Parker Appliance Co. These were used for flow meters, draft meters and similar instruments. A feature of the exhibit was the new production bending machine, specially designed for manufacturers or companies doing a great deal of bending of the larger size tubing.



At the exhibit of the Brown Instrument Co., a number of new instruments were shown; among them, a long distance recording pressure gage which operates as far as 7 mi., a forged steel high-pressure manometer for flow meter service on pressures as high as 1400 lb. and a low range manometer giving full scale deflection on a differential of ½ in. water. Also on display was the first strip chart flow meter, a new flow controller and flush mounted strip recorders for switchboard service. One of the most recent developments is a thermometer with a temperature range of 85 to 110 deg. designed primarily for hospital service, to give a reading within 0.2 deg.

For indicating drafts as high as 60 in. of water, the Ellison Draft Gage Co. developed and had on display its new mercury element pointer draft gage, also exhibiting a new Pitot tube designed for measuring air or gas flow and the two-pointer dial type draft gage, showing the uptake and furnace draft on a single instrument, the pressure difference between the two being apparent to the fireman at a glance.

Using the same element as that of the recorder, the Leeds & Northrup Co. exhibited a new frequency controller for regulating the frequency of a generator driven by a steam or water turbine. A new frequency indicator, using the same principle said to have an accuracy of 0.1 cycles, was also shown.

Gratings and Steel Products

Blaw-Knox Co. showed its new Floorgard, which is a steel armoring for concrete floors and pavements. This is made up of steel strips formed into a regular pattern

which, when placed together, form a series of separate rectangles of proper size to meet the condition.

Water Treatment

Semi-automatic water softeners recently developed by the Crane Co. were featured at that company's booth. This is a household zeolite unit with a capacity of 22,500 gr. between regenerations.

Demonstration of the principle and efficiency of its new purification and control equipment was made by the Elgin Softener Corp. by means of a small model boiler; an external deconcentrator, consisting of a settling chamber, collects the precipitates carried out by

the natural circulation of the water between the upper and lower drums. The solids settle at the bottom of this chamber and are blown off periodically. By means of charts and drawings, the action and operation of their treatment and equipment independently and in combination with zeolite softeners were shown. The system takes care of the boiler battery as a whole and allows individual treatment for the separate boilers.

New steel poles, known as Type 4 and built to heights 45 ft., were a feature of the exhibit of the Walter Bates Steel Corp. These poles were made of four angles with a standard lattice and are of extremely simple and rugged type. The company also had on display armored, reënforcing grating for conduit and by means of photographs drew attention to its new steel frame housings.

In addition to its standard grating, steps and armoring, the Irving Iron Works Co. showed its railroad crossover, designed primarily for use on railroad crossings.

William F. Klemp Co. displayed its new Type C treads with small openings of 5/8 in. designed for use primarily in locations where women pass, the opening being so small it will not take the ordinary small heel.

At the booth of Graver Corp., a new chemical proportioner was shown. In this device, as water flows through a water meter installed in the main water line, the action of the meter is transmitted to a reduction gear by means of a steel cable which works a swing pipe in the chemical tank. This swing pipe is raised or lowered so that as water flows through the main line, more or less chemical will be admitted to the swing pipe, to the chemical pump, which sends it to the mixing tank.

Automatic electric evaporators for testing boiler feed water was featured by the National Aluminate Corp., who also exhibited a number of new developments, including a hydrometer for boiler feed work and a corrosion tester which consists of a small element which is inserted in the boiler while it is in service, the action of the water and steam on this element being used as the basis for determining conditions of treatment.

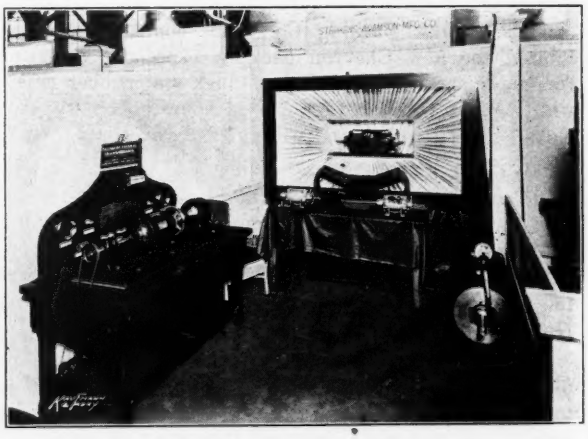
A recently perfected electro-magnetic proportioner of solenoid type for lime-soda ash softeners was featured by the Paige & Jones Chemical Co., Inc. This proportioner is actuated by a solenoid, which, in turn, is operated by the gear wheel of a water meter, so that the chemical feed must of necessity be proportional to the amount of water going through the meter.

Miscellaneous

Bates & Rogers Construction Co., in an exhibit of photographs, featured the Crawford Ave. and Waukegan stations, the construction of which they have recently completed.

On a large scale map, the Commonwealth Edison Co. showed in color the transmission lines of the important public service companies of the United States and effectively demonstrated the net work of transmission lines which now cover the country.

Power plant models used by the Detroit Edison Co. in its station design and layout were shown in the booth of the Detroit Edison Co. Models exhibited were a Del Ray No. 3 boiler which will soon be in service, the Wills Ave. heating plant and the Trenton Channel No. 4 unit, which has been in service for some time.



Propeller fans for cooling tower service were featured by Foster Wheeler Corp. Another item of interest was a model and photograph of the 4-high air cooler section for the new section of Philo station.

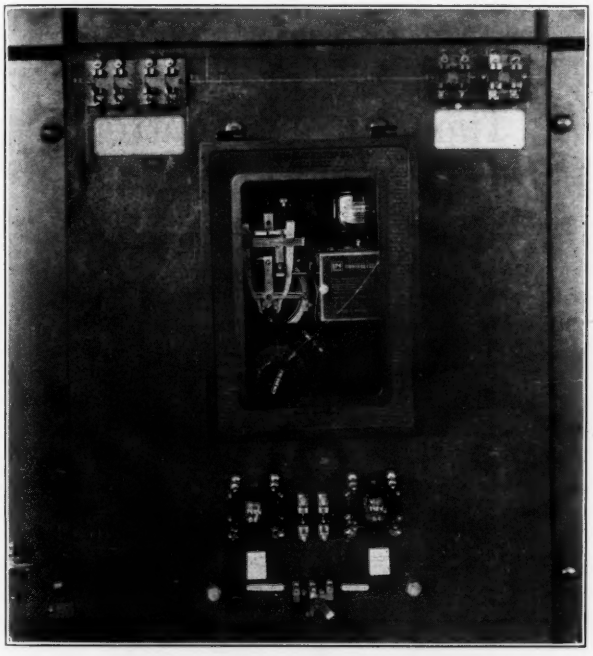
At the booth of Veeder Root, Inc., a comprehensive display of devices for counting was found. One of the most interesting applications shown here was a counter for automobile traffic, another registered each time a shadow was cast by a lamp. This has found application in the protection of bank vaults.

The Radiac machine for cutting tubing, bar or flat stock of cold rolled steel, nickel steel, high speed and other types of steel, as well as many alloys, was shown by A. P. deSanno & Son. The cutting element of this machine is an abrasive wheel operating at a single speed of about 5000 r.p.m.

Power Plant Engineering Developments and News

Automatic Frequency Controller

TO CONTROL frequency within relatively close limits by direct connection of a controller to the governor regulating motor on a steam or hydraulic turbine, the



AUTOMATIC FREQUENCY CONTROLLER MOUNTED WITH ACCESSORIES ON SWITCHBOARD PANEL

automatic frequency controller, shown here, has been developed. The controller is of a proportional step type, designed automatically to send out an impulse to the turbine governor regulating motor proportional to the frequency deviation from the control point. If frequency is low a definite amount, the controller will transmit an impulse to the regulating motor of a duration and direction suitable to cause the governor to speed up the turbine and bring the frequency to the control point within close limits. The converse applies if frequency is high. Since the controller operates in steps proportional to the frequency deviation from the control point, it is stated that there is no tendency for the control to overtravel or "hunt."

The control point on an instrument adapted for nominal 60-cycle operation may be adjusted over a range from 59 to 61 cycles. This adjustment can be made at any time to overcome any slight cumulative frequency error and to hold a correct average as indicated by a synchronous clock.

In a typical installation, the "raise," "lower" and "common" leads from the controller are connected through suitable relays to the turbine governor regulating motor. If there are several turbine generators in the power station, the automatic control can be placed on the largest machine and the others will naturally keep in synchronism with it so that the effect will be sufficient to control the whole station and possibly the whole system. When the control is connected to a single turbine generator and the frequency is at the normal point, the load should be somewhat below full generator capacity so that there is a leeway for governing.

The controller uses the same impedance bridge circuit that is employed in the company's frequency recorder. By use of this circuit, it is stated, calibrations are accurate and permanent and temperature coefficient and usual voltage variations are negligible.

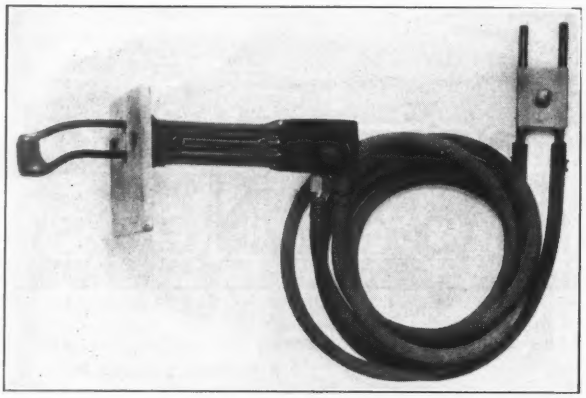
The mechanical parts of the controller are identical with those that have been employed in the proportional-step temperature controllers. The new controller is a recent product of Leeds & Northrup Co., Philadelphia, Pa.

Water-Cooled Carbon Electrode Holder

ANNOUNCEMENT HAS recently been made of an entirely new type water-cooled carbon electrode holder for heavy duty manual welding by the carbon arc process. Designed primarily to insure greater comfort and less fatigue for the welder operator, it has been found after extensive tests in the manufacturer's plant that the new holder effects a marked economy in the use of the carbon electrodes.

Due to the efficiency of the design of the electrode holder, it is possible to weld with the arc tip of the carbon electrode projecting less than 3 in. from the carbon holder. Consequently there is less carbon area heated, it is claimed, thereby greatly reducing the vaporization of the carbon. Thus it is possible to use smaller size carbons with higher current density which effects a decided saving in electrode costs.

One of the features, which contributes to the light weight of the holder, is the use of the hose that carries the water to also carry the cable to the holder. Each of the two water tubes contains a small light cable from the connector to the holder. The water flowing through the holder also acts as a cooling agent for the cables.



LINCOLN WATER-COOLED CARBON ELECTRODE HOLDER, TYPE W

By the use of this cooling agent, the size cable to the holder is reduced to a fraction of the size necessary if it were not used.

The carbon holder consists of coiled copper tubing through which water constantly circulates, the carbon electrode being inserted through the coil. The carbon holders are manufactured in sizes for use with ¼-in., $\frac{5}{16}$-in., ⅜-in. and ½-in. carbons. A hand shield of compressed magnesium protects the operator's hand from the arc rays. The water cooling system is incorporated also in the hand grip of the holder to keep it cool.

The new type water-cooled carbon electrode holder and flexible water cooled lead-off cable are being placed on the market by The Lincoln Electric Co., Cleveland, Ohio.

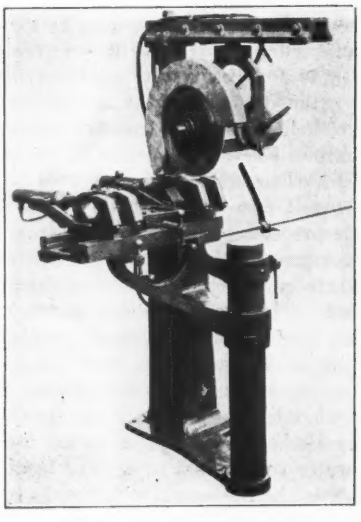
DeWalt Wonder Metal Worker

AS SHOWN HEREWITH, a new metal cutting saw has been developed by the DeWalt Products Corp., Leola, Pa., known as the DeWalt "Wonder Metal Worker" for cutting seamless steel tubing and formed metal where a smooth rapid cut is required. The DeWalt "Wonder Metal Worker" is a 5-hp. overhead direct-drive circular, metal-cutting saw adjustable to any angle, for cutting tubing up to 3 in. in diameter, ⅛ in. wall thickness; it operates at 3600 r.p.m.

It was first developed to meet the needs of the aeronautical industry in making the many angle cuts necessary in the construction of the fuselage of the planes. The material chiefly used is molybdenum steel, one of the hardest alloy steels.

This Wonder metal worker is equipped with 12-in. hollow-ground, metal-cutting saw. This saw should give three to four days' continuous operation in cutting ⅛-in. wall molybdenum steel tubing before resharpening, when it is touched up with an ordinary hand file. Eight to ten days is the usual service on low carbon steels before resharpening. A manual feed is provided for regular even pressure feeding of the saw through the material.

For holding the work, an air grip vise, developed by the engineers of the Travel Air Mfg. Co. of Wichita, Kan., which firmly grips and feeds the tubing the desired length, is available. This operates on 30 to 150 lb. air pressure. The jaws of the vise are adjustable to handle tubing up to 3 in. diameter.

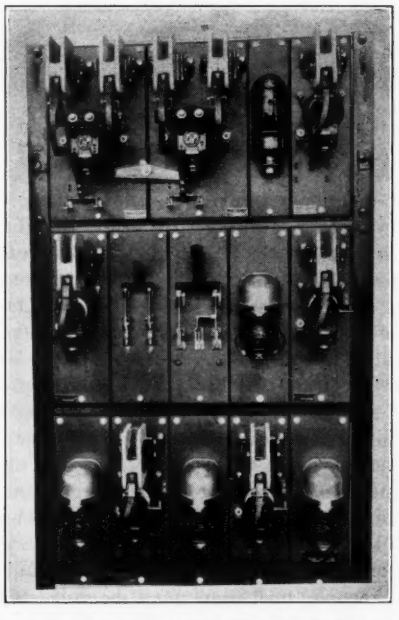


WONDER METAL WORKER HAS ADJUSTABLE SAW

Time Current Control

INCORPORATING AN ENTIRELY new principle, the new system of time current control recently developed and placed on the market by the Electric Controller & Mfg. Co. of Cleveland, O., is claimed by the manufacturers to possess several valuable characteristics. This system is designed to permit at all times and under all conditions the fastest possible manipulation of mill drives and other motor operated equipment.

Under abnormal conditions, the Time Current Control system lengthen out the time interval of the acceleration steps, giving the motor more time to get under way. Even if the motor fails to start on the first step, the second step closes after a delay of two seconds. If this does not force the motor to start the



NEW E. C. & M. CO. TIME CURRENT CONTROLLER

third step will close, increasing the torque until the motor eventually starts.

On a cold morning, for instance, when starting up with gear grease cold, the Time Current Control automatically adjusts itself to the abnormal conditions and starts the motors without punishing them. As the bearings and gears limber up the controller responds to the easier conditions and in a short time the equipment will operate at full speed.

This system is controlled by a new Time Current Acceleration Relay developed for the purpose.

Unit Pulverizer of Recent Design

IN THE ACCOMPANYING illustration is shown a coal pulverizer recently placed on the market. This is made in all sizes; the unit shown, of one-ton-an-hour capacity is 8 ft. 6 in. long, including driving motor, 32 in. wide and 8 ft. high and is provided with a 25-hp. motor. Starting power is stated to be 6⅔ hp.

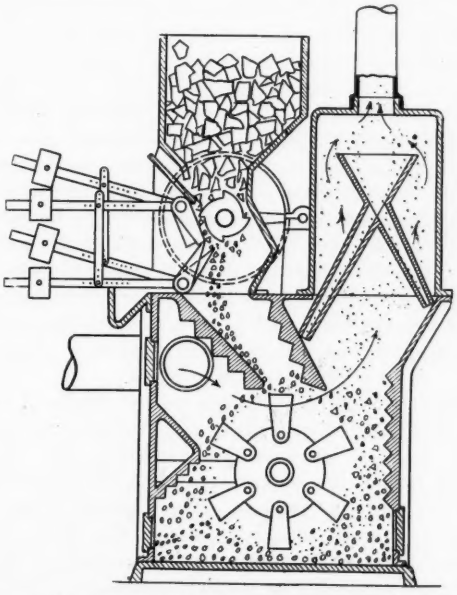


FIG. 1. CROSS-SECTION SHOWING FEEDER MECHANISM AND PULVERIZER ROTOR

Coal flows from the loading hopper to the rotating feeder and three compound extractors are provided to eject any hard material too large to pass the feeder jaws. Other tramp material less than ½ in. in size passes through the feeder and falls out of the coal stream to the bottom of the pulverizing chamber, from which it is removed through cleanout doors.

Pulverizing of the coal is effected by a rotor carrying swing hammers as shown. These are slightly twisted to produce a vortex action in the pulverizing chamber; also they are of varying lengths to prevent stratification. Pulverized coal is drawn off at the top, to permit any degree of fineness desired, the heavier particles falling into the separator, which returns them to the pulverizing chamber.

Two end plates and one side plate may be removed to permit the S.K.F. heavy-duty bearings of the rotor to slide forward on shelving provided for that purpose. This is to allow free access to the rotor, for changing hammers or reversing wearing surfaces, without removing the top of the machine.

Rotor is driven at 1800 r.p.m. directly from the driving motor, without intervening gears. A belt running from a pulley on the shaft between motor and pulverizer rotor drives a pulley on the feeder shaft at 18 r.p.m.

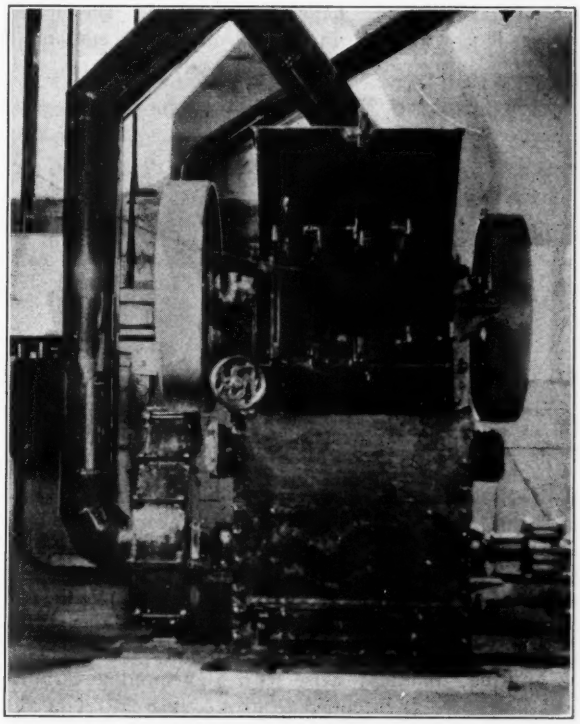


FIG. 2. EXTERIOR VIEW OF THE NEW PULVERIZER

This pulverizer has been placed on the market by R. W. Hulburt, 1045 18th St., Des Moines, Iowa, business manager for W. L. McLaughlin and associates, who developed it, Mr. McLaughlin being the patentee.

THE DELAWARE POWER & LIGHT CO., Wilmington, Del., a subsidiary of the United Gas Improvement Co., Philadelphia, Pa., is arranging a 1929 expansion and improvement program to cost about $2,235,000. The work will include construction of new power substation in the western section of the city to furnish service to Newark, Yorklyn, Newport, Hockessin, and vicinity; installation of additional equipment at substation at Stanton; extensions to transmission lines and distributing system, and miscellaneous work. Thomas W. Wilson is president.

PRODUCTION OF ELECTRIC POWER by public utility power plants in the United States for December, 1928, according to the latest report from the Geological Survey, Department of the Interior, reached a total of 7,869,860,000 kw-hr., an increase of 9 per cent from the output of December, 1927. Of this amount, 5,115,074,000 kw-hr. were generated by fuels and the remainder by water power.

Slow-Speed Centrifugal Governor for Steam Turbines

NEW AND INTERESTING application of the centrifugal governor to a steam turbine is demonstrated by the Pickering governor as installed on the Coppus Type TF steam turbine, as shown in the accompanying illustration. This device, made by The Pickering Governor Co., Portland, Conn., consists of centrifugal governor balls supported on the usual springs but with their axes horizontal, the motion of

PICKERING SLOW-SPEED GOVERNOR ON COPPUS TURBINE

the balls actuating the governor valve controlling flow of steam to the turbine nozzles. This governor is driven at slow speed by a worm and gear from the turbine shaft, the gear being mounted directly on the governor head.

This arrangement is designed to give a slow-speed governor and thus to eliminate governor trouble, such as hunting, that may arise with high-speed governors. The low speed is intended to give longer travel of the valve for a given speed variation of the turbine, thus providing more stable regulation, unaffected by wear, the slightest amount of which may cause hunting.

Model 539 Current Transformer

FOR USE with a one-ampere instrument for making alternating-current measurements from 0.2 to 200 amp., a new current transformer, the Model 539, has been

CURRENT TRANSFORMER PERMITS READINGS FROM 0.2 TO 200 AMP.

developed. The transformer has a 1-amp. secondary and four self-contained primary ranges of 2, 5, 10 and 20 amp. changed by a range-changing switch shown on the top of the transformer. Ranges of 200, 100 and 50 amp. are available by passing the conductor one, two or four times through the hole in the transformer provided for that purpose. This is known as an inserted primary. The new transformer and the 1-amp. Model 528 instrument with which it is intended to be used, are made by Weston Electrical Instrument Corp., Newark, N. J.

Soviet Engineers Study American Hydroelectric Practice

A. V. WINTER, chief engineer, and B. E. Vedeneev, assistant chief engineer of the Dnieper electric power plant under construction in the Soviet Union and six other leading Soviet technicians have arrived in this country to study American hydroelectric development and to participate in negotiations in regard to placing orders for several turbines for the plant, with a capacity of 80,000-hp. each.

The Dnieper power station will be equipped with 10 such turbines, and will attain a capacity of 800,000-hp., making it the largest hydroelectric power plant in Europe. The construction of the Dnieper power plant was started two years ago, some 60 mi. below the city of Dnepropetrovsk, in the Ukraine. Hugh L. Cooper & Co. have been engaged as consultants on the project, which will involve a total outlay of $100,000,000.

The Dnieper dam, which will be completed within 3 yr., will raise the level of the water in the Dnieper River 122 ft. This will result in raising the water above the rapids which are located several miles above the site of the dam and will make the Dnieper River navigable in that section. Sluices will be built connecting the upper and the lower streams of the Dnieper.

"We have come to the United States," said Mr. Winter, "in the belief that the American machine building firms, with their great experience in hydraulic machinery construction, will be interested in the technical problems involved in the construction of hydraulic turbines for the Dnieper power plant.

"The tremendous electrical power that will be developed by the Dnieper plant will be used not only by the many industrial establishments which are to be constructed around the Dnieprostroy but will also be transmitted to outlying regions. The United States, with its distances approximating those of the Soviet Union, has made greater advances in long-distance transmission than probably any other country. Therefore, several members of our delegation will study long distance transmission in this country, with a working voltage up to 220,000 v., as well as factories producing the required equipment.

"American equipment and technical skill are being employed on the construction of the Dnieper power plant to a greater extent than on any other project in the Soviet Union. It may be said that nearly 70 per cent of all the equipment that has been ordered for the plant is of American manufacture. The importance of the Dnieper power plant for the economic development of the entire country is great, as the cheap electric power will make it possible to build up a number of industries, such as the manufacture of fertilizers, ferromanganese, aluminum, and so on, which require cheap power for successful operation."

DUE TO CONDENSER LEAKAGE, condensate is not always free from impurities.

Work Started On New Power Station for Duquesne Light Co.

ACTUAL CONSTRUCTION WORK on the James H. Reed power station to be built on Brunot Island, Pittsburgh, for the Duquesne Light Co., has been started, according to H. W. Fuller, vice president in charge of engineering and construction, Byllesby Engineering and Management Corp. Orders have been placed for the major equipment, turbines, boilers, stokers and condensers.

This new station will have a rated capacity of 60,000-kw. The building to be constructed at this time will be large enough to house two 60,000-kw. generators, and six boilers, but only one 60,000-kw. generator and three boilers will be installed now. The extra space provided is for future additions to the station capacity.

Main building will consist of an electrical gallery and offices, a turbine room with spaces above the roof trusses for station auxiliary electrical equipment, and a boiler room. A circulating water pump and screen house will be located north of the present switch house on the bank of the Ohio River. The buildings will be of brick, tile and concrete construction with steel frame supported on concrete piling. The exterior of the brick walls of the buildings will be of face brick similar to the present Brunot Island switch house.

One coal tower having a capacity of 200 t. per hr. will be installed for the purpose of unloading barges from the main channel of the Ohio River. The coal tower structure will contain a receiving hopper feeding a 200-t. per hr. crusher, the crusher discharging into an inclined elevated belt conveyor which will run from the coal unloading tower to a point approximately 75 ft. northeast of the present switch house.

News Notes

PLANS HAVE BEEN APPROVED for the consolidation of electric light and power companies operating in the vicinity of Buffalo, N. Y., to include the Buffalo, Niagara & Eastern Power Corp.; Niagara, Lockport & Ontario Power Co.; Niagara Falls Power Co.; Buffalo General Electric Co.; Tonawanda Power Co., and the Lockport & Newfane Power & Water Supply Co. The consolidated organization will be known as the Niagara Power Corp.

AT THE LAST MEETING of the stockholders of D. H. Skeen & Co., 1362 Monadnock Block, Chicago, Ill., D. S. Walker was elected vice president of the company. The company also announced that H. W. Neblett has joined the Skeen organization, specializing in work for steel mills and similar industries. Mr. Neblett, a graduate of the University of Tennessee, was for several years with the engineering department of the Commonwealth Edison Co. and for 12 yr. has been employed in steel mill engineering.

FROM BERLIN, Germany, an order for fuel-burning equipment for the new West Central Station in that city is reported by the American Engineering Co. of Philadelphia.

This new station will be at the opposite end of the city from the Klingenburg Station, which is fired by pulverized coal. The equipment to be supplied includes eight Taylor stokers water-cooled furnace armor and ash removal arrangements. The stokers will have a capacity of 600,000 lb. of steam an hour each and will be 20 retorts wide and 49 tuyeres in length. Air for combustion will be heated to 500 deg. F.

ON JANUARY 1, The Prest-O-Lite Co., Inc., acquired the business of the Acetylene Products Co., which operated two plants located in Phoenix, Arizona, and El Paso, Texas. Everett R. Kirkland is superintendent of the Phoenix plant, and Carl F. Chesak of the El Paso plant. R. G. Daggett, whose headquarters are at the San Francisco office, is district superintendent.

G. H. KUECHLER will have charge of the Detroit branch office of Thomas E. Murray, Inc., recently established in the Eaton Tower, Detroit, Mich.

LINCOLN ELECTRIC CO., Cleveland, Ohio, announces the appointment of C. M. Taylor as sales manager.

AIR PREHEATER CORP. announces that its address has been changed from 25 Broadway to 40 East 34th St., New York City.

BROWN INSTRUMENT CO., Philadelphia, Pa., announces that its Buffalo, New York, office is now located at 402 Marine Trust Building, having recently removed from 624 Ellicott Square. The company also announces that O. B. Wilson has been placed in charge of the Cleveland office, 819 Hippodrome Building, Cleveland, Ohio.

FORT PITT STEEL CASTING CO., McKeesport, Pa., announces that W. J. Corbett has resigned as secretary-manager of the Steel Founders' Society of America to become assistant to the president of the Fort Pitt Steel Casting Co.

W. C. WEST CO., Chicago, Ill., industrial sales representatives for Central Valve Manufacturing Co., is now represented in the Michigan territory by Garrett Burgess, Inc., 5522 Underwood Ave., Detroit, Mich.

CHAIN BELT CO., Milwaukee, Wis., announces that W. H. Brand, vice president of the First Wisconsin Co., has been elected director of the Interstate Drop Forge Co., which is affiliated with Chain Belt Co.

MATTHEW GRISWOLD, who retired as manager of the Erie (Pa.) Works of the General Electric Co. on January 1 of this year because of ill health, died at his home in Erie on February 10. Mr. Griswold was born in Erie in 1866 and was graduated from Sheffield Scientific School, Yale, in 1888. After two years of post graduate work, he obtained the degree of M. E. Upon leaving college, he became associated with the Griswold Manufacturing Co., of which he served as president for a number of years. On November 11, 1911, he severed his connection with the Griswold Manufacturing Co. to become acting manager of the Erie Works of the General Electric Co. He was made manager of the plant on December 12, 1912.

AT THE FORMAL ground breaking of the Byers new $10,000,000 plant at Ambridge, Pa., on Feb. 11, Secretary of Labor James Davis made a number of remarks significant of what the Byers new process might mean to the ferrous industry.

"Heretofore the effort had been to create a machine that would imitate the movements of a human worker," he said. "All such efforts failed. Now the metallurgist

has stepped in and brought success. He has known better than to try making a machine take the place of a man. Instead of a machine he has invented a process. And where the machine always failed, the process works.

"The part of it which has convinced me of its success is the dropping of the old idea of the 'heat' and substituting a ball of iron weighing 2500 to 3000 lb. and making this in a short time.

"There is a saving, too, because under the old method, in the production of 2500 to 3000 weight of iron, with two crop ends to the ball, three balls to the heat and five heats to a day, there were 30 crop ends but with this new process there are but two crop ends to the same weight; and while, as just stated, it formerly required a day's labor to produce this weight of iron, it can now be produced in half an hour.

"This new process will mean increased production, too, which means giving employment to more men, cheapening the cost of iron so that more of it can be sold and used and perhaps opening new industries for the working of iron into new products, with still further extension of new jobs to new men.

"In the long run, every new process or method or machine that improves or speeds production and cuts down its cost in money and labor, is a boon to humanity."

C. C. GILLETTE, former vice-president and general manager of the Public Service Co., Wheeling, W. Va., has joined the Rockford, Ill., Gas and Electric Service Co. as manager of the electric division. Mr. Gillette was formerly traffic manager and head of the research department of the Pittsburgh Railway Co., Pittsburgh, Pa.

AMERICAN HOIST & DERRICK CO. of St. Paul, Minn., has opened a branch office at 139 Townsend St., San Francisco, Calif., in charge of Boyd Nixon. The company also announces the appointment of F. E. Bauer, Jr. as export sales manager, with offices at 50 Church St., New York City.

ANNOUNCEMENT HAS just been made by the Kitts Mfg. Co., Oswego, N. Y., that on the first of the year the company was purchased by the O'Connor Brothers. The business will be conducted as in former years, manufacturing the same line of specialties with the addition of one or two special patented features.

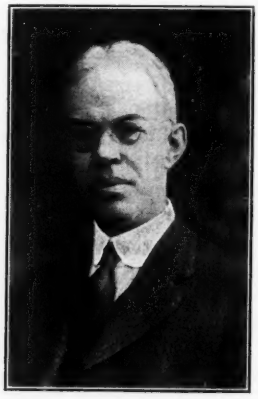
MONARCH METAL CO., Chicago, Ill., announces with deep sorrow the death of its president, Herbert L. Lemon, on January 30, 1929.

SOUTHERN CALIFORNIA EDISON CO., Los Angeles, Cal., has completed pile driving and foundations for an addition to its steam generating plant at Long Beach. Contract for structural steel for the superstructure has been awarded to the Llewellyn Iron Works, Los Angeles, Cal. Stone and Webster, Inc., Laughlin Building., Los Angeles, are engineers and general contractors.

BOARD OF TRUSTEES, Harvard University, Cambridge, Mass., is having plans drawn for a new steam power plant for central heating service, reported to cost about $75,000 with equipment.

PLANS TO ADD 100,000 kw. of generating capacity, in the form of two units, to its Station A plant in San Francisco are announced by the Pacific Gas & Electric Co. Preliminary plans call for two 50,000-kw. compound turbine units operating under approximately 1400 lb. steam pressure. These will replace two small units totaling about 27,000 kv-a. in the present plant. Natural gas will be used as the nominal fuel, and with the size of the units and the high steam pressure involved it is expected that the plant will show unusually high economy. Plans call for the first unit to be in operation 18 mo. after work is started.

SAMUEL WYLIE MILLER, consulting engineer of the Union Carbide & Carbon Research Laboratories, Inc., of Long Island City, N. Y., well known both in the United States and in Europe as a pioneer in oxyacetylene welding and an authority on its application, died on February 3 at his home in Hollis, Long Island, N. Y., at the age of 62. Mr. Miller, a native of New York, received his degree in Mechanical Engineering from Stevens Institute in 1887. His first professional activities were as master mechanic for the Pennsylvania



Railroad plants at Logansport, Indianapolis, Ind., and Columbus, Ohio. Following this, he was with the American Locomotive Co. at Dunkirk, N. Y. and Providence, R. I., after which he founded the Rochester Welding Works at Rochester, N. Y. During the World War, he served on the Welding Committee of the Emergency Fleet Corporation. In 1921, he joined the newly formed Union Carbide and Carbon Research Laboratories, Inc. He was a director and past president of the American Welding Society, a director of the American Bureau of Welding and chairman of the Oxy-Acetylene Committee of the International Acetylene Association. He was an active member of the American Institute of Mining and Metallurgical Engineers, American Society for Steel Treating, British Iron and Steel Institute, Institute of Metals and other scientific and engineering organizations.

LEGISLATION to clarify Illinois laws regarding the rights of cities to purchase utility power; increase of bonding power to provide financial means of construction and expansion of municipal power and light plants as well as other public projects and reëstablishment of "home rule" in the matter of negotiating franchises with utility companies, will be major objectives of the Illinois Municipal League this year in the general assembly, it was decided at a meeting of the officials and legislative committee of the league in Springfield recently.

The first proposal to clarify current laws has been brought to a crisis by the suit of the Illinois Power and Light Co. against the Consolidated Coal Co. of St. Louis and the Consol Power Co. now pending in the appellate court. The plaintiff alleges that the coal company is intruding in its territory and has enjoined the coal concern from construction of a power transmission line between Staunton, Williamson and Livingston. The Illinois Power and Light Co. claims its certificate of convenience and necessity to serve the community traversed by the proposed transmission line gives it sole rights in that field, while the coal company pleads that its purpose is primarily to generate power for coal mines and that sale of surplus power to cities wholesale is an unimportant and secondary consideration in its activities.

The league wants a statute which will give cities, with a distribution system but without municipal plant or finances to erect one, the right to buy power wherever they can. The league is also desirous of having the bonding power doubled from the present 2½ per cent limit to 5 per cent of the assessed valuation. It is said that 150 cities and towns in the state now have municipal distribution or power plants. In the matter of "home rule" legislation, the league hopes to deprive the state commerce commission of all authority within municipal boundaries insofar as utilities are concerned. On the other hand, the organization is preparing to fight renewal of the effort to place municipal plants under control of the commission. Mayor Charles H. Bartlett of Evanston is president of the league and Mayor O. W. Smith, Decatur, heads the legislative committee.

NORTHWESTERN POWER CO., operated by the Winnipeg Electric Co., will proceed with the construction of the new hydroelectric plant at the Seven Sisters Falls on the Winnipeg River, with ultimate capacity of 225,000 hp. The entire project, including transmission lines, will involve the expenditure of about $18,000,000. It is expected that the initial unit will be ready for service in about 18 mos.

PACIFIC GAS & ELECTRIC CO., San Francisco, Calif., has authorized plans for remodeling and extending its local steam power plant, involving an expenditure of about $5,500,000 to increase its capacity to about 175,000 hp. Closely following this, work will proceed on another unit to develop a capacity of 300,000 hp. for the entire plant.

CITY COUNCIL, Centralia, Wash., plans a bond issue of $1,000,000 for the construction of a municipal hydroelectric plant to be operated in conjunction with the present city-owned station and distribution lines. A site has been selected on the Nisqually River, near McKenna, where the initial plant is expected to consist of two 2500-hp. generating units.

ILLINOIS PUBLIC UTILITY CO. has been authorized by the Illinois commerce commission to construct and operate transmission lines into and serving the community at Burtonview, in Logan County.

NEW BRITISH COLUMBIA POWER CORP., operating the British Columbia Railway Co., Vancouver, B. C., has approved plans for a new hydroelectric project near Ruskin and the enlargement of a similar development now under way at Bridge River. The Ruskin project now under way at the Stave River will be carried about 3½ mi. below Stave Falls, where a power dam will provide head of 125 ft. The initial installation will consist of a single generating unit of 43,000-hp. capacity, with provision for another similar unit as soon as the load necessitates it. Operation is scheduled early in the fall of 1930. The work at the Bridge River development will consist of the completion of the power plant and installation of a 220,000-v. transmission line. W. G. Murrin is president of the railway company.

PLANS AND SPECIFICATIONS are being drawn and prepared for a new high-tension substation for the Lakeside Malleable Castings Co., Racine, Wis. Installation of a large air compressor and other plant changes are also contemplated. Ottomar H. Henschel of the Henschel Engineering Co., 401 Commerce Building, Milwaukee, Wis., is the engineer.

BOARD OF TRUSTEES, Easton Hospital, Easton, Pa., plans the construction of a boiler house for steam heat service in connection with an expansion program. A complete laundry will also be installed. The Ballinger Co., 12th and Chestnut Sts., Philadelphia, Pa., is architect and engineer.

EMMETSBURG, Iowa, electric light and power plant, the first constructed by the Municipal Utilities Co. of Des Moines, Ia., under its plan of retiring cost of construction from earnings, has been completed and is in operation. Two 240-hp. full Diesel type engines furnish the power.

AT THE GRAND RAPIDS, Mich., plant of the Hayes Body Corp., a 500-hp. Stirling boiler with Taylor forced-draft stokers, Mason pressure regulators and Copes feedwater regulators has recently been installed. American boiler feed pumps, a Cochrane feedwater heater and a Worthington 23 and 14 by 16-in., 1740-c.f.m. synchronous motor-driven compressor were installed at the same time. J. H. Chalmers is plant engineer.

MILWAUKEE ELECTRIC RAILWAY & LIGHT CO., Milwaukee, Wis., is carrying out extensions in its Lakeside steam power plant, estimated to cost about $700,000. John Anderson is vice president and chief engineer.

Books and Catalogs

INDUSTRIAL CARBON, by C. L. Mantell; published by D. Van Nostrand Co., Inc., 8 Warren St., New York, N. Y.; 301 pages; price, $4.50 net.

A comprehensive, interesting treatise on carbon in all its industrial forms from diamonds down to pencils. To the power plant engineer, its chief interest lies in the chapters on Electrodes, Carbon Brushes, Arc Light Carbons, Carbon Specialties and Battery and Welding Carbons.

STABILITY OF METALS AT ELEVATED TEMPERATURES, by Claude L. Clarke and Albert E. White. Published by the Department of Engineering Research, University of Michigan, Ann Arbor, Michigan, as Bulletin 11. 122 pages; price, $1.00.

Research on this subject was undertaken for the purpose of answering three questions: First, what relation, if any, exists between the results obtained from short-time tensile and long-time creep tests? Second, what are the factors affecting the stability of metals

at elevated temperatures? Third, what mathematical relationship exists between the variables encountered in long-time testing?

In regard to the first, it has been concluded that whether or not any relationship exists between these two forms of testing depends entirely upon the temperature range being considered.

In regard to the second, it is felt that the stability may be increased by increasing the strength of the weakest phase present. That above the equi-cohesive temperature, the amorphous phase is the weaker, while below, the crystalline phase is the weaker of the two.

In regard to the third, mathematical equations have been developed connecting together stress and time for any particular temperature and any particular metal.

INTRODUCTION TO THEORETICAL PHYSICS, by Leigh Page; published by D. Van Nostrand Co., 8 Warren St., New York, N. Y.; 582 pages; price, $6.50.

A careful but highly theoretical and mathematical presentation of modern theoretical physics which requires a working knowledge of calculus and differential equations to follow the development of the theories step by step. The subject matter is divided into five main divisions; dynamics, hydrodynamics, thermodynamics and the kinetic theory of gases, electro-magnetism and optics, and spectroscopy. As one of the most complete and latest treatments of the field of physics, this book has a place in the library of every engineer who follows hydrodynamics and thermodynamics from the theoretical as well as the practical side.

STEAM TURBINES, by James C. Moyer; published by John Wiley & Sons, Inc., New York, N. Y.; sixth edition, 527 pages; price, $4.50.

In the preparation of this edition, special attention has been given to calculations for the design of steam turbines. New sections have been added to the enlarged field of application of bleeder and extraction turbines, variation of steam consumption with age, new shaft and diaphragm packings and casing design.

HANDBOOK OF REFRIGERATING ENGINEERING, by W. R. Woolrich, 5 by 7 in., 331 pp., illustrations, tables and charts, cloth; price, $4 net; D. Van Nostrand Co., Inc., New York, N. Y., 1929.

Designed for operating and constructing engineers as well as for students in engineering courses, this book has been planned as a combined text and reference. Tables and data from engineers and manufacturers as well as from the author's experience have been included.

Starting with definitions and fundamental principles, the requirements for cold storage and refrigerating mediums are taken up. Details of the ammonia compression system and various types of the required apparatus are treated, including compressors, condensers, pipe and brine systems, capacities and electric drive.

Principles and practice of the absorption system are given in two sections. Carbon dioxide and sulphur dioxide, each has a section.

Features of ice-making systems are considered and methods of testing a plant are outlined.

Special refrigerants are treated briefly but as fully as their importance warrants.

In the last part, details of the boiler plant and properties of steam are given briefly, largely in the form of tables.

Throughout, tables and charts of data are used freely to amplify the text and as convenient references to aid in calculations. Illustrative examples are worked out and problems at the end of each section give practice in the use of formulas and tables. Also questions emphasize the most essential points of the text.

Designing and operating men should find this book a convenient, concise and handy reference as to principles, operating procedure and methods of calculation.

REPRINT OF paper by W. O. Renkin, New York, and presented before the World Power Conference, London, 1928, deals principally with the use of powdered coal in the iron and steel industry, touching upon its use in some nonferrous metal work. Copies will be sent to those who request this reprint by writing to the Combustion Engineering Corp., 200 Madison Ave., New York, N. Y.

HAYS FLUE GAS ANALYZERS and portable combustion test sets are completely described in recent bulletin issued by the Hays Corp., Michigan City, Ind. Purpose of flue gas analysis, features of construction of the instruments and methods of using them are discussed in detail. The company is also issuing a bulletin describing Bestix and asbestos boiler setting cement designed for covering boiler brickwork.

NEW DESIGNS of the Ljungstrom air preheater, made possible by the development of the new type of heat element, are discussed in a recent folder of the Air Preheater Corp., 25 Broadway, New York, N. Y., sent out by its agents, D. H. Skeen & Co., 1362 Monadnock Block, Chicago. The latter company is also sending out an attractive folder describing various types of forged steel valves made by the Edward Valve & Manufacturing Co., East Chicago, Ind.

POWELL STEEL VALVES are described and illustrated in a recent loose-leaf bulletin of 34 pages sent out by The Wm. Powell Co., Cincinnati, Ohio. Tables of dimensions, price lists and tables of working pressures and temperatures are given in connection with each type of valve.

QUEEN POTENTIOMETERS and accessory instruments are described in bulletin E-4 by Gray Instrument Co., 64-70 West Johnson St., Germantown, Philadelphia, Pa.

TORSION, impact and other mechanical properties of SAE-3130 nickel-chrome steel are given in bulletin No. 13 by the International Nickel Co., Inc., 67 Wall St., New York, N. Y. Data are given covering tests that appear to show that the properties of this steel vary less than heat to heat than those of other steels.

HOPE VACUUM PAPER CONDITIONER designed to prepare sheets of paper for obtaining perfect register in printing and lithographing is described in a 4-page folder by Hope Fan & Blower Co., 1509 Central St., Kansas City, Mo.

RECENT DEVELOPMENTS in Evaporating Systems, a paper by Thomas Shipley, read before the November 22, 1928 meeting of the N. A. P. R. E. at Louisville, Ky., is reprinted in full, with all illustrations and data tables, in bulletin No. 142, which is being sent out by York Ice Machinery Corp., York, Pa.

FOR AIRPLANE MOTORS, high power with low weight are essential in order to increase the useful load. To achieve this condition, nickel and alloy steel have been largely used in the Curtis D-12 and Conqueror aircraft engines which have powers of 435 and 625 hp. respectively and weights of 1.565 and 1.21 lb. per hp. Both are 12-cylinder V-type, water-cooled and use 0.53 lb. of gasoline per horsepower-hour. Details are given in a bulletin issued by The International Nickel Co., Inc., 67 Wall St., New York City.

FLOAT-AND-SINK Testing of Fine Size Coal is the title of bulletin 46 of the U. S. Bureau of Mines. Copies may be had from the Engineering Experiment Station, University of Washington, Seattle, Wash.

IN FOLDER No. 290, sluice gates with adjustable wedges are described by Rodney Hunt Machine Co., 101 Lake St., Orange, Mass.

HORIZONTAL GENERATORS for water-wheel drive are described and illustrated in a four-page leaflet L-3556-A, issued by Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

THE BOILER HOUSE in the Oil Refinery is the subject of a reprint bulletin sent out by Combustion Engineering Corp. 200 Madison Ave., New York, N. Y. The article, by Walter Siegerist, deals with tendencies toward higher pressures, modern fuel burning methods, water-cooled furnaces, air preheaters, waste heat boilers and plant auxiliaries. Copies may be had on request.

IN A NEW BULLETIN, No. 158, on small vertical motors in all types and in ratings of ⅛ to 1½ hp., Wagner Electric Corp., St. Louis, Mo., discusses the details and applications of these motors. They all have the same flange or lug dimensions and are equipped with a labyrinth seal to prevent leakage of lubricant into the motor windings and to provide a dustproof bearing housing.

STEPHENS-ADAMSON MFG. Co. of Aurora, Ill., announces a new 24-page skip hoist catalog. It describes the company's complete line of skip hoist equipment, including data on sizes and capacity. This catalog also presents information on the S-A style "SD" skip hoist machine. The latter is made in three sizes, each size furnished with a number of different arrangements with motors and gears to give the desired speeds and capacities.

IN FORM No. 1059, Dreadnaught buckets are described and illustrated by Blaw-Knox Co., Pittsburgh, Pa. These buckets are equipped with ball bearings and are furnished in many different capacities for all types of material handling service.

HOW TO BRONZE-WELD Cylinder Blocks is told in a recent 12-page well-illustrated bulletin by the Linde Air Products Co., 30 East 42nd St., New York City.

STRATTON VERTICAL JET FURNACE, designed to burn in suspension crushed bituminous coal (not pulverized) is described in a recent bulletin issued by Stratton Engineering Corp., 341 Madison Ave., New York, N. Y.

THE IDEAL ELECTRIC & MANUACTURING Co. of Mansfield, Ohio, has just published a copyrighted circular No. 501, entitled "Flywheel Effect Recommendations for Air Compressors Based on Ideal Synchronous Motor Drive." This bulletin is illustrated with installations, graphic curves, etc. It presents information on how to obtain flywheel effect for any type, horsepower or speed, the curves being based on a standard motor of 100 hp. at 200 r.p.m., 60 cycles. An example at the bottom of each page shows definitely how to use the curve for each type of compressor.

IMPROVED V-NOTCH METERS with recorders, as recently described in detail in these columns, are described and illustrated in bulletin No. 679 by the Cochrane Corp., 17th St. and Allegheny Ave., Philadelphia, Pa. Bulletin No. 677 discusses steam purification, giving data on causes and prevention of contamination, while bulletin No. 682 describes the Cochrane discharger, a large capacity steam trap for pressures up to 1350 lb. per sq. in. The Cochrane tandem blowoff valve, as recently described in these columns, is illustrated and discussed in a new folder.

AUTOMATIC ARC WELDERS for steel railroad ties are described in bulletin GEA-1022A by General Electric Co., Schenectady, New York. Bulletin GEA-1084 describes plate-type field rheostats for motors and generators in sizes of 6, 10, 12 and 15-in. for 125, 250 and 600 v. Bulletin GEA-823B gives many interesting data regarding automatic hydrogen arc welding equipment for hand welding on 50- and 60-cycle circuits only. This is designed for welding in hydrogen by a continuous independent arc.

TYPICAL BUCKEYE DIESEL TYPE ENGINE installation in a 30-t. ice plant is described in a 4-page bulletin sent out by the Buckeye Machine Co., Lima, Ohio.

BULLETIN No. 35, devoted to stock sprockets and chain which are available in various localities has recently been issued by the Morse Chain Co., Ithaca, N. Y. The data are arranged so that two or three different designs can be selected to meet specifications in sizes from 1 to 25 hp. and can be obtained within 48 hr., bored and keyseated to fit the shaft.

TYPE 4-A ANTHRACITE DUMPING GRATE designed to give high efficiencies from small sizes of anthracite is the subject of a recent 8-page bulletin issued by McClave-Brooks Co., Scranton, Pa. Complete details of the grate are given with description of the integral parts and illustrations of applications.

STURTEVANT TEMPER VANE HEATING units are described in an attractive 44-page illustrated bulletin, No. 363, by B. F. Sturtevant Co., Hyde Park, Boston, Mass. Comparative performance curves for various types of vanes are shown, illustrations of smoke tests of the heater, details of its component parts and a comprehensive engineering analysis to show the method of selecting the proper type and size of heater for various applications. Full page charts are included for calculating any condition that will be met in selecting heating units.

IN A RECENT ISSUE of The Delta Star, published by Delta Star Electric Co., 2400 Block, Fulton St., Chicago, Ill., photographs show some of the details of its new type F substation construction.

OPPORTUNITIES FOR ENGINEERS in the United States Civil Service, including a table showing the salaries and distribution of government engineers, are discussed in a bulletin, Form 2599, issued by the United States Civil Service Commission, Washington, D. C.

Power Plant Construction News

Ala., Gadsden—The Goodyear Tire & Rubber Co., Akron, Ohio, will install power equipment in proposed rubber reclaiming mill for which plans have been approved, estimated to cost $1,000,000. Structure will be a unit of large branch plant at that location.

Ala., Mobile—The Todd Shipyards Corporation, 25 Broadway, New York, will install power equipment in connection with extensions and improvements in branch plant at Mobile, Ala., to cost about $200,000.

Calif., Tracy—The Holly Sugar Corporation, Colorado Springs, Colo., plans installation of power equipment in proposed addition to beet sugar mill at Tracy, entire project to cost about $200,000.

Calif., Watsonville—The Apple Growers' Cold Storage Co. has approved plans for a one-story cold storage and refrigerating plant on the Beach Road, 300 x 500 ft., to cost about $240,000, with equipment.

Conn., Bridgeport—The United Illuminating Co., New Haven, Conn., has plans under way for an addition to its steam-operated electric generating plant at Steel Point, Bridgeport, reported to cost more than $250,000. Company will also build a one-story equipment storage and distributing plant on East Main Street, Bridgeport, 118 x 225 ft., reported to cost more than $90,000. Westcott & Mapes, Orange Street, New Haven, are engineers for the power plant project.

Conn., Hartford—The Hartford Electric Light Co. is having plans completed for a three-story equipment storage and service building, 160 x 180 ft., at 404-10 Sheldon Street, to cost more than $100,000. Smith & Bassette, Hartford, are architects; F. J. Reynolds is company engineer.

Conn., Meriden—The New Departure Mfg. Co., Bristol, Conn., will install power equipment in proposed four-story factory for ball bearing manufacture on Pratt Street, Meriden, estimated to cost $350,000. Lockwood, Greene Engineers, Inc., 24 Federal Street, Boston, Mass., is architect and engineer.

Ga., Atlanta—Power equipment, including boiler house, pumping station, motors, etc., will be installed in a proposed new cotton mill to cost about $3,000,000, in vicinity of Dalton, Ga., for which plans are being drawn by Robert & Co., Atlanta, Ga., architects and engineers. Company name is temporarily withheld.

Idaho, Payette—The American Crate & Basket Co., 4700 Clarkson Street, Denver, Colo., plans installation of power equipment in proposed new plant at Payette, entire project estimated to cost about $150,000.

Idaho, Lewiston—The Wenatchee Beebe Fruit Co., Lewiston, L. H. Rose, local manager, has approved plans for cold storage and refrigerating plant in connection with addition to packing plant, entire project to cost about $80,000. R. C. Stockton, Perkins Building, Tacoma, Wash., is engineer.

Ill., Chicago—The Murphy-Ward Dairy Co., 2016 Calumet Avenue, will install power equipment in proposed central milk and dairy plant at Dearborn and Twenty-first Streets, entire project to cost more than $150,000.

Ind., Bloomfield—The Showers Brothers Co., Bloomington, Ind., plans installation of power equipment in proposed addition to branch plant at Bloomfield to cost more than $100,000.

Ind., Indiana Harbor—The Inland Steel Co., 38 South Dearborn Street, Chicago, will install power equipment in a proposed expansion and improvement program at plant at Indiana Harbor, including two new mills and other units, entire project reported to cost more than $4,000,000.

La., Mangum—The Creola Carbon & Gasoline Corporation, care of B. A. Irwin, 2 Giddens Lane Building, Shreveport, La., recently organized, plans installation of air compressors, pumping units and other power equipment in connection with proposed carbon and gasoline plant in vicinity of Mangum, entire project reported to cost upward of $250,000.

Me., Bangor—The Bangor Hydro-Electric Co., 84 Harlow street, has plans under way for an addition to power plant, reported to cost more than $150,000. F. A. Patterson, 16 Central Street, is engineer.

Md., Annapolis—The Board of Water Commissioners and the Annapolis Water Co., City Hall, plan installation of pumping equipment in connection with extensions and improvements in municipal waterworks, including filtration plant, entire project to cost more than $200,000. W. C. Monroe, City Hall, is city engineer.

Mich., Flint—The Board of Water Commissioners, City Hall, has preliminary plans in progress for a water purification plant for the municipal waterworks, reported to cost close to $2,000,000, with equipment. Alvord, Burdick & Howson, 8 South Dearborn Street, Chicago, Ill., are engineers.

Mo., Galena—The Eagle-Picher Lead Co., St. Louis, plans installation of power equipment in connection with a $250,000 expansion and improvement program at plants at Galena and Smelter Hill, Mo.

Neb., Omaha—The Jerpe Cold Storage Co., 1114-16 Douglas Street, has filed plans for the construction of a four-story addition to cold storage and refrigerating plant to cost about $60,000, with equipment. J. T. Allen and N. S. Wallace, Brandeis Theatre Building, are architects.

N. Y., Utica—The Skendandoa Rayon Corporation, Broad Street, will install power equipment in proposed two new plant units, entire project to cost approximately $3,000,000. Beecher M. Crouse is president.

N. D., Harvey—The Central Light & Power Co., Dubuque, Iowa, is reported planning a steam-operated electric power plant at Harvey, estimated to cost about $100,000, for general commercial service in this municipality and neighboring towns.

Ohio, Canton—The Hoover Suction Sweeper Co., North Canton, will install power equipment in two new four-story plant units, entire project to cost more than $250,000.

Ore., Hillsboro—The Portland Electric Power Co., Portland, Ore., plans one-story equipment storage and service building at Hillsboro, to cost approximately $50,000. Ralph Easter is division manager.

Pa., Lansdale—The Franklin Pottery Co., Lansdale, plans installation of power equipment in proposed addition to tile manufacturing plant, entire project reported to cost upward of $100,000. Franklin & Conver, Lansdale, are architects.

Tenn., Alcoa—The Aluminum Co. of America, Inc., Oliver Building, Pittsburgh, Pa., will install power equipment in proposed bronze powder mill at Alcoa, Tenn., entire project reported to cost close to $1,000,000.

Tenn., Nashville—The du Pont Cellophane Co., Park Avenue Building, New York, will install power equipment in proposed new mill at Old Hickory, near Nashville, for the manufacture of transparent wrapping material, entire project to cost more than $1,500,000. Company is a subsidiary of E. I. du Pont de Nemours & Co., Wilmington, Del.

Texas, Beaumont—The Magnolia Petroleum Co., Dallas, Texas, will install power equipment in connection with an expansion and betterment program at its oil refinery at Beaumont to cost more than $2,000,000, including pumping plant, with capacity of 25,000 gals. per min., gas converting plant, boiler plant, tanks, etc.

Texas, Elsa—The Central Power & Light Co., San Antonio, Texas, has approved plans for cold storage and refrigerating plant at Elsa, reported to cost more than $70,000, with equipment.

Va., Richmond—The Standard Paper Mfg. Co., Hull Street, plans installation of power equipment in proposed addition to mill to cost about $400,000.

Va., Waynesboro—The Central Atlantic States Service Corporation, 40 Goble Street, Newark, N. J., is said to have plans under way for new cold storage and refrigerating plant at Waynesboro, Va., to cost upward of $200,000, with equipment.

Wis., Milwaukee—The American Lace Paper Co., 908 Juneau Avenue, will install power equipment in proposed four-story addition to plant on the Port Washington Road, entire project to cost in excess of $100,000. Richard Philipp, 405 Broadway, is architect.

Wis., Stevens Point—The State Board of Regents, Capitol Building, Madison, is having plans completed for construction of two-story central steam heating plant at normal school at Stevens Point, to cost about $65,000, with equipment. J. C. White, 624 East Main Street, Madison, is architect.